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MALTING AND BREWING.

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SELECTION

OF THE

PRACTICAL POINTS

OF

MALTING AND BREWING,

AND

STRICTURES THEREON,

FOR THE USE OF BREWERY PROPRIETORS.

BY

JAMES STEEL,

302, St. Vincent Street, Glasgow.

SMITHSONIAN
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DEDICATION.

Dear Sir,

It has long been my fancy to write a brewing book, and lend such aid as I could to disenchant the brew-house, and drive thence the malignant incubi, which for generations have kept possession. A recent period of leisure has enabled me to fulfil my wish, and I am now in need of a patron. Among my old friends no one has had a longer or larger experience of the trade, practically or commercially, than you—no one knows better the difficulties which beset the profession—no one has seen more of its ups and downs, or been so often called in to advise or assist its members as you have, your servant among the rest; and so no one can be better fitted to judge of a brewing book, or be the patron of a good one when it appears. From these considerations, and in respect of old associations, I wish to dedicate my effort to you, trusting you will accept the position, and that the book will be found not unworthy of your patronage.

I am,

Yours truly,

JAMES STEEL.

Hugh Baird, Esq.,
Cathkin House,
Glasgow.

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PREFACE.

A WRITER in an *Encyclopedia Britannica* says:—"Though the Art of Brewing be undoubtedly a part of chemistry, and certainly depends on fixed and invariable principles as well as every other branch of that science, these principles have never yet been investigated. *For want of a settled theory, therefore, this art is found to be precarious, and to succeed unaccountably with some, and misgive as unaccountably with others.*"

So far as principles are concerned, Brewing is no further forward than when this gentleman wrote in the year 1796, and so, like him, the author proposes to give a few hints to help to establish a proper theory of the art. The chemist has hitherto been helpless in the brewery, because, not having learned the art of Brewing, he could have no theory, and having neither art nor theory, his presence has as yet done more harm than good. When the chemist has been presented with the facts of the position and a base to operate from, he will doubtless become in the brewery, as elsewhere, of the highest utility.

The following abstract of Brewing experience is the result of a long-past determination to take the mystery of

the manufacture of beer out of the hands of quacks and empirics, and place it so that the capital invested in its manufacture may have protection from those most interested in it—viz., its owners. Hitherto the money placed in the Brewing Trade, fabulous as the amount of that money has been, and is, has been no better protected than if it had been exposed in a game of chance, while the difficulties of the situation have found no relief by offering or giving the largest of salaries to the practical brewer. The men with the requirements to work out the problems involved in Brewing concerns, except in rare instances, are not to be found for wages; they are not in sufficient numbers for the requirements of the trade, and increased salaries mean no more than so much additional money going to waste, or giving no return.

The author has no intention to injure the practical brewer, but rather, if possible, improve both his and his employer's position by giving the latter the power to head his own concerns, and take the responsibility attaching thereto when circumstances require it.

This treatise is meant to serve as a catechism in the hands of the capitalist—free of technicalities and super-scientific mysticism—by which he may by a few questions judge of the intelligence of his brewer, check his procedure, and set him right when his practice is wrong, or help to put his material right when it is out of proper condition: and it will be equally useful to test the quality and experiences of a new brewer when changes of management take place. A large work might have been made up of drawings, examples of Brewings, calculations, statistics, &c., as has so often been

done before, and the treatise interlarded with the rules, remarks, and conjectures of former book-makers, but it would have only been to bury the few facts known in the practice of Brewing away in a mass of verbiage and useless matter, and brought confusion to the mind of the reader.

Brewing books hitherto have been quite indefinite as to information on malt-drying or curing. Combrune's much-quoted experiments on the heat of dried malts are quite worthless, as he performed them on a close-bottomed vessel, and so they cannot apply to aught but black malt. None give definite mash-heats, either for a first, second, or third mash, or sparging-heat, unless it be the water copper-heats sometimes given, and all of them, except Levesque, send the brewer downstairs to his under-back to study tap-heats when he wants information of the condition of his mash-tun. Levesque, however, is so inaccurate as to give a first goods heat at 10° too low, and a last goods heat at 10° too high. Books brought out before the thermometer or saccharometer period must necessarily be vague, and some of them are curiosities, but although these valuable instruments have come into general use, books have not improved. "Richardson" gives a thick volume on Brewing, but tells absolutely nothing, except it be that the reader ought to go to him and pay —— guineas and get the secrets of the art. "Roberts on Ale-brewing" tells a something, which something is, that if the first tap-heat be so-and-so the first mash has been right, and if the first mash be right he will allow anyone to dictate the sparging-heat to him from 180° up to 204°. This reckless statement has done, and is still doing, an

incalculable amount of mischief, for such an assurance has prevented investigation in a most dangerous direction. "Mr. Black" evinces practical talent, but only a brewer of experience can find, amid his theories on electricity and magnetism, that among his plans for setting brewers right, who were working badly, was the infallible one of re-drying the malt. And yet, though he has hold of this most important point, he talks quite erroneously of kiln heats, and kiln procedure—even allowing malt to be *cooled* on the kiln. A work written by a Mr. Stewart and a Professor Thomson, purchased and read by the author many years ago, mentioned that malt could be used with greater safety a fortnight off the kiln than when older, and so one good point, if no more, was made by these authors. "Tizard's" book on Brewing is very unsafe, and has set everyone wrong who followed its teaching. His plans of superheating the goods to take out extracts which were not in the grain went beyond safety, and those who went into them were glad to beat a retreat and fall back on old ways. The celebrated practical chemist, Muspratt, indulges in a treatise on Brewing, but he says nothing of practical use. His sources of inspiration seem to have been Dr. Bottinger and Mr. Tizard. Liebig, too, writes voluminously on Brewing to illustrate the Bavarian method, but no Bavarian could brew from his book. He lays stress on the peculiar fermentations in the practice of the Bavarians, but seems to have not the slightest idea of why or wherefore their fermentations are so peculiar, attributing it all to cold. The writer in the *Encyclopedia Britannica* already alluded to is

the only one of the writers on Brewing met with by the author who recommends lower after-heats, but such a work was not likely to fall into the hands of practical men, and amongst them, though not unknown, the practice has never got fully established. Strange to say, the article on Brewing in the recent *Encyclopedia* is not so valuable as that in the one of eighty years earlier.

A Mr. Ford in 1849 gives a book on Malting and Brewing, which, except for its explanations of Excise law and store of general statistics, is useless to a brewer. He dries pale malt at 100° or 110° in 36 or 48 hours, introduces Mr. Black's *bete noire* electricity, and shows his ignorance of the whole subject in the following quotation:—"Let a brewer's experience be ever so great, not one yet has been enabled to ensure *a perfect uniformity in all his fermentations.* There are many causes operating to produce this irregularity —First, the presence of sulphur in all hops, and more or less in malt. Second, the high temperature at which fermentations are generally conducted. Third, the imprudent arrangement of the plant rendering perfect cleanliness impossible from the quantity of metal pipes and wort pumps. Fourth, electricity. Fifth, the want of a uniform character, quality, and colour in malt."

One of the reasons Mr. Ford gives for bad fermentation is, that fermentation is conducted at too high a temperature, and yet *his* one good point is his statement that fermentations must not rise over 75°.

At the end of 1873 and the beginning of 1874, Dr. Graham of the London University was spirited enough to

deliver lectures on Brewing to the Society of Arts. These lectures contain matter that will be useful to the men of the future, but to the men of the present the matter is simply useless, unless for the purpose of taking them away from their present bearings and leaving them at sea, without lighthouse or headland to steer by. The Doctor's acquaintance with practical brewing seems somewhat slight. Still to a brewer of experience, and possessing a knowledge of chemistry, the lectures may have been instructive, as showing the chemical basis of our brewing material. He follows up Dr. Ure and others on the question and importance of dextrine in beers, but he does not show how, within reasonable limits, the proper amount of dextrine can be obtained or regulated. The raw or partially malted corn he recommends as a source of that body, can hardly be admitted, and brewers dare not go up and down with mash-heats in the reckless way indicated by him. His mashing inspirations seem to have been drawn from the Germans, but these do not apply to English brewing. He has a glimmering of the advantage of the coke and kiln gases saturating the malt, but does not press the method of drying with them on his audience, believing apparently that though coke-dried may be better than air-dried malt, still the latter will make brewing malt—which it will not do—for English brewing.

Traps are set everywhere for the poor brewer. Mr. Scamell, the Brewers' Engineer of London, in a recent and valuable work on Breweries and Brewing Machinery, talking of Kilns, goes out of his way to tell brewers that the proper manner to dry malt is to do so with air heated by steam

pipes, and driven through the malt by fans. No man could give worse advice, and Mr. Scamell's name is quite sufficient to cause inexperienced maltsters and brewers to follow his dictations. If any have done so, the sooner they retrace their steps to the kilns of their grandfathers the better for them.

A Mr. Faulkner, who claims to have been a pupil of the late Mr. Young, of Messrs. Truman and Messrs. Hoares, London, has last year given his lucubrations on brewing to the world. The book is modestly and patientfully written; but 'tis all chemistry, all about the proportions of sugar and dextrine, and little about practical experiences and results. The author should not have touched depreciatingly a work so very recent, but that it contains, if not a trap, a fallacy of a dangerous kind. Mr. Faulkner gravely asserts that malt does not benefit by being re-dried. This is contrary to fact, as no man ever re-dried his malt without instantly benefitting his beer if he knew how to mash, but Mr. Faulkner as well as Mr. Young's fallacies are all covered by the remarks to follow.

ERRATA.

Page 32, line 18, for "*Their* thinner mashes" read "*The* thinner mashes."

Page 38, line 28, for "*have* discovered" read "*had* discovered."

Page 49, line 5, for "beneficial to *their* beers" read "to *the* beers."

Page 50, line 17, for "*imboil*" read "*inboil.*"

Page 72, lines 16-17, for "lowered for the first *half hour*" read "for the first, *half-an-hour.*"

Page 116, line 23, for "time of second *infusing*" read "time of second *mashing.*"

MALTING AND BREWING.

WATER.

Analyses of the waters in districts where good beer is made show that they contain a large quantity of foreign matter in solution, and the principal and best ingredients are evidently carbonate and sulphate of lime. The part these play in the Art of Brewing is left to the chemists of the future to elucidate, but it is well known that both these salts are useful, and that it is better when *both* appear in water from which beer is to be made, though London supplies the proof that the carbonate in itself is sufficient for porter.

It looks as if the carbonate were a principal and most necessary ingredient in beer water, for though the beers from pale malt benefit by the sulphate in some way, the products of browned and roasted malt do not, but are injured by it in quantity. And so pale beer may be said to be best with an excess of sulphate, and black beer with an excess of carbonate of lime, in the water. It does not seem as if large quantities of these ingredients were wanted—nor does it seem that anything else is wanted, for the other

components of analysis vary so much, without advantage or detriment to the beer, that they may be held (if not in large quantity) to be neutral. The presence of a moderate quantity of carbonate and sulphate of lime seem to be powerful to neutralize the effects of quantities of organic matter in water, and 10 to 20 grains to the gallon of each appear to be sufficient for brewing the best of ales. Of course it is of the utmost importance to have water free of organic impurity.

Water is doctored sometimes by the introduction of matters into the water cisterns or coppers to improve it when too soft, and with considerable success. Gypsum (sulphate of lime) being easily soluble, is much used in lumps, one to two inches square, in the cold-water cisterns, and as flour in the hot-water coppers. A method of hardening water by a natural process is shown in the plates at the end of the book. It consists of passing water in spray through a body of carbonic acid gas and over limestone. The plate explains itself. Examples of the principal brewing waters are likewise given.

BARLEY.

Barley of the best quality ought to be selected to make malt for the purposes of the brewer, as both the perfection of the malt, and the quality of the beer to be made from it, depend much upon this consideration.

Barley passes under its national designations, and is imported from various countries, but, to judge of the article, the greatest weight per bushel, the quality and condition being ascertained regulates the price. The quality is estimated from the colour—a delicate pale yellow—its plumpness, thinness of skin, its free chalky fracture, and absence of flintiness in look and behaviour when broken, and its sharpness, or thorough finish of growth. It is best from comparatively light soils, from the marl tracts and chalky bottoms of England, and improves on the sea margin generally, apparently from the saline conditions of earth and air in the neighbourhood of the sea. Early harvested barley has always the advantage over that which is unseasonably late, and has been taken up before it was completely matured.

It is of great importance to the maltster that barley be lodged in the stack a few weeks before thrashing, so that the soil moisture may have exuded, or sweated off before it comes to his hands; when this is not the case the process of kiln drying must be resorted to, to dry and equalize the conditions of dryness in the grain before wetting.

Light showers or dews before or after cutting are said to reduce the hardness of barley and make it to free better on the malting floor; these influences, however, just as often do harm as good, as the least excess of moisture, from any cause, unaccompanied with sunshine, causes fermentation and discoloration, and, in consequence, incipient decomposition.

After a wet, dull season, grain often heats in the rick, and becomes greatly reduced in value for malting and brewing purposes, and, if not rendered altogether unfit for use, it will nevertheless, when malted, want proper flavour and sweetness, will be liable to go quickly out of brewing condition, and if brewed make dull, mawkish, unsound beer. Heated barley is at once known by the blackened ends, and by the growth germ, or plumule—which should be of a butter colour—being darkened, or rotted away altogether; of such barleys sometimes not 10 per cent. will germinate.

After thrashing, barley can be kept sound only by weekly turnings, exposed to an abundant supply of air, or by kiln drying, and putting away in a thick heap. Kiln-dried barley will keep sound over a season, without requiring a scoop (or shovel) being put into it, and if put away in close bins will keep maltable for years.

Maltsters ought never to depend on new barley to commence operations at the beginning of a season, but should have one or two months' stock of old on hand, to make them independent of the fluctuations of autumnal weather, of barley thrashed direct from the field, and of excited markets and high prices invariably attending a late harvest.

In moist districts, where grain never gets thoroughly

dried, even in the rick, barley should always be kiln-dried before being applied to malting purposes, as the purifying gases from the fuel sweeten the corns, and give them power to pass through the spireing stage without fungusing. In kiln-drying the temperature ought not to be allowed to rise much over 120°, and great care should be exercised against the temperature rising higher.

Malting barley should all be screened so as to have it of equal size and stamina on the spireing floor, and in this country it saves duty to eliminate the small light corns before steeping. It is of the utmost importance that barley be moved about with great care, and fracturing avoided by treading, &c.; and so limit to a minimum the chances of mould in the spireing process.

The practice of allowing 1s. per quarter extra on anything over 54 lbs. per bushel for country barley is very detrimental to the malt, as the over-dressing knocks off the ends, and causes it to mould on the floor.

Foreign barleys from all parts of the world are now of necessity used by brewers, and with advantage. Many of them are very light, from 44 to 50 lbs. per bushel, but as they are all from hot countries, and have tasted of superior sun power, they are safe to brew. The smallness or thinness of their corns makes them easily dealt with on the kiln, and thus are a protection to the brewer against the carelessness or selfishness of the maltster; of course, on the market their value is in relation to the amount of extract they give, plus or minus their quality, when once that is established.

STEEPING.

The season's operations should not begin until the heat of the weather is such that the floors can be kept at a temperature not exceeding 50° Fah. In Scotland, the wetting goes on from the 1st of October to the 1st of May, but in the south of England the last steep should not be later than the 1st of April; of course, there is irregular working at warmer periods, but this is exceptional, and need not be considered in relation to legitimate malting, or in the making of malt for fine beers.

Steeping is permitted only once in four days, and only six floors are allowed in a house at one time. The steeping hours vary considerably; the excise in this country compel the maltster to keep his barley under water for at least 40 hours, and in making malt for sale, some people make their barley do with little more, to save duty, making up the deficiency of water with sprinkling; but parties malting for their own use will steep sometimes in frosty weather as long as 90 hours. The mean periods of steeping, however, when malt is meant to be conscientiously made, may be stated as 60 hours for light, and 72 hours for heavy barley, and these hours are found to be quite short enough, as even with them in a dry condition of atmosphere a little sprinkling is sometimes found necessary.

Sprinkling, however, should be avoided, and the duty honestly paid, as by this course the best malt and the best

beer is made, and the superior extract in quantity and quality is always compensation for the extra duty. Sprinkling is only allowed after a 50 hours' steeping, and on notice being given.

Of late years fine malt can scarcely be had to purchase, the brewers want to buy cheap, and the maltsters want large profits; and thus between the two, short steeping hours, sprinkling of floors, and low drying have become quite the fashion. Even large and respectable firms, whose traditions and experiences might tell them better things, have been sacrificing their money and their characters as brewers, to get hold of the delusive savings accruing from short steeping hours.

Partially made malt, the product of short steeping hours, will not yield quality nor yet extract, for high class or strong beers. The extraction of these forced malts requires a range of mash-heats nearly equal to that employed by the raw grain distiller, together with the acids and alkalies at his command, and the aid of such a quantity of water as is incompatible with beer brewing. In this treatise the author shall use the term beer only for white beer, as, although beer and ale have different significations in different localities, the term beer is becoming general as a title for all brew-house products.

To the brewer who would give his "Experts" justice, who would have good beer and stand well in the market for regularity of product, and make money, the long hour system of steeping as well as flooring is simply imperative.

The key to malt-making lies in a knowledge and attention to the fact, that the decomposition of vegetable matters sets

in, and proceeds with greater velocity, as the temperature to which they are exposed rises; and so, if barley is meant to be made into good malt, it must be kept throughout the operation at a heat under the decomposing temperature. To effect this it must have a free supply of air, and to bear the supply of air it must have in it plenty of moisture, to prevent its drying up and dying on the floor before the acrospire has come to its proper state of advancement.

Another potent reason for the grain being steeped to softness, is the necessity of a good root; and a much stronger, bushier, and healthier one comes away from well-steeped barley than from that which is understeeped. In the one case double the number of radicals will be projected to make up the root than from the other; and as the strength of the root is, so is that of the acrospire, and the quality of the malt. A weakly root is synonymous with flinty malt, and mean flavour.

The root seems to be a product of the fermentation of the elements of the corn, and for that fermentation to be efficient some fixed (and as the author thinks ascertainable) condition of softness, to allow of motion among the atoms of which the corn is composed, must be a necessity. If this be the case, it is logical to infer that the corn as a whole must be the basis of a proper root development, that the imperfect root is the result of an insufficiency of moisture and of a defective fermentation, and that no after supply of moisture, given in detail by sprinkling, will serve the purpose of a thorough steeping, which ought to have been supplied at the outset of the process.

The law of England insists on the barley being covered all the time it is in the cistern, unless a notice to uncover has been given at the same time as the notice to steep; but water may be kept running off from below the grain, and on above, throughout the steeping hours, so long as the top of the charge does not get uncovered. A change of water once in the day is sufficient, unless when the grain is inferior, and has been heated in the rick or on shipboard, and in this case a running off from below, and on above, is necessary to wash away the fermented matters adhering to the skin of the grain. Barley is known to be steeped if the skin bursts readily when the ends are crushed betwixt the finger and thumb.

Cisterns must not exceed 40 inches in depth, and must have 48 inches of clearance overhead; cast-iron is the most suitable material for making them of, and they ought to be furnished with a complete false bottom to drain off all superfluous water, and prevent the couch being sloppy at one part and dry at another, or have standing pools in it, while the grain remains for gauging.

The finest water should be used for steeping, as well as for brewing. When the water is soft, and the grain not quite sound, a few handfuls of finely ground chalk should be dusted over the contents of the steep. The carbonic acid gas emitted from barley in the process of steeping, will cause the water to absorb the chalk, and thus remove acidity.

When summer malting is resorted to, spring water should be used, and it ought to be kept running on above,

and off below, all through the steeping hours, so as to keep down the temperature. The barley should be well steeped, and taken from the couch the instant it is free, and spread out on the floor, to a thickness of not more than 3 inches.

COUCHING.

The Excise compel the steeped barley, when removed from the cistern, to be thrown within a square or rectangular shaped frame placed alongside for accurate measurement or gauging. The frame is in skeleton and made up on the spireing floor, alongside the steep, and must have three of its sides fixed, and at right angles to each other. The moveable side, which allows of the grain being turned out, must be made of timber at least two inches thick, and properly supported to prevent bulging. The sides, or the grain within, must not be deeper than 30 inches, practically in regard to the grain it is placed from 12 inches to the full depth allowed; the thinner a couch is the better to maintain a low temperature in the grain. The Excise allowance for swell here, as well as in the cistern, is $18\frac{1}{2}$ per cent., but after leaving the couch, and entering into the floor state, and thence through the kiln, the allowance is 50 per cent. The grain has to remain in couch for 26 hours, except in summer, when, if the officer has gauged it, it may be removed at the expiration of 20 hours: this regulation is in the interests of the maltster, as a rise in the heat, and sprouting in the couch, where it is not under command, is very detrimental to the quality of the malt.

During the malting season the heat of the cistern contents ranges from 35 to 45 degrees Fah., and rises 1 or 2

degrees in the couch, but in very severe weather it frequently gets lower, and the maltman has sometimes to heap it 2 or 3 feet thick, and even cover it up after leaving the couch for a length of time to get the roots to spring; this, however, happens only in extra severe weather, or in exposed houses, and the general practice is to thin out from the couch, more or less, according to the temperature of the time being.

SPIREING.

When the grain is discharged from the couch frame, it is spread out, as has been already said, thicker or thinner according to the state of the weather, but so as to keep the temperature as near 50° Fah. as possible for five or six days, and the process of thinning it out generally goes on during that period. After this stage the grain does not readily take harm, and it is kept growing gradually with a slightly rising temperature, until the acrospire reaches the limit allowed on the floor, that is, to between a third and a fourth part of the length of the corn from the end.

Very little turning is required in the early stages of the spireing process; and when the grain gets thinned out, ploughing for a time is quite sufficient to control the heat, if it suits the state of the house, and that without so much oscillation of temperature as with turning. A low temperature is everything in the early stage of the spireing process, and close attention ought to be given to the floors to prevent them from heating. In the event of heating, the result is a driving out and loss of the moisture, a dropping off of the roots, a stopping of the progress of the acrospire, and an indifferent malt. The operation of spireing is very much a question of the graduation of temperature between the couch and the kiln, and could the floors be so regu-

lated as to rise a degree a day after the first six days, without much fluctuation between the periods of turning or ploughing, perfection would almost be attained. With the regulation of temperature, the other matter of importance, viz., a free admission of air, must be maintained. All vegetable matters in a stagnant atmosphere will degenerate into fungus, and so will malt in progress of spireing run to mould, if air be not freely supplied; and thus, whether or not air be necessary to convert the constituents of barley into starch, we have here a reason for not sparing it in maltmaking. Besides all this, a free supply of air is indispensable to keep down the general temperature of the malthouse, and floors do not readily dry if kept cold. Thermometers of a suitable kind ought to be freely used in the malthouse, as a means of education to the workmen. The rising heat is easily detected by experienced maltsters, as it is accompanied by increase of bulk, which presses the grain together and hardens the floors so much, that in walking over them the change is readily felt with the foot. Floors ought to be spread out well at night to keep them safe till morning, unless night attention be given, as it ought to be to the young floors.

The time necessary to be expended between the steep and the kiln for good brewers' malt, runs from 12 to 16 days, according to weight of barley, and allowing for weather. Distillers push their work through in 8 or 10 days, but make an article unfit for brewers' purposes. If temperature be kept down, and the malt being made be from 54 to 56 lbs. barley, the longest time stated will be quite taken up to make a really free malt. With regard to some of the light

foreign barleys, the shorter time may suffice, as a little increase of temperature is not so fatal to quality as in the case of the heavy home sorts.

The method of examining the progress of the spire, and freeing of the malt, is by nipping off with the nails of the thumb and finger of either hand the unmalted end of the corn, *i.e.*, the end opposite the root, and seeing how far the spire has ascended, and how much of the other end is free. As the spire ascends, the kernel through which it has passed assumes the condition of flour and spreads out betwixt the thumb and finger like as a pinch of fine flour. Malt which has been under-steeped or overheated in the early stage of spireing, or made of flinty barley, does not behave as regards freeness in the manner mentioned, but keeps hard and lumpy, and rolls between the fingers much as a fragment of any unripe kernel would do.

The maltsters of half-a-century ago aimed at having their malt thoroughly withered before it went to the kiln, and had withering lofts for the purpose. In this the author believes they were right, as putting malt too early on the kiln, its damp state causes a great loss of mash-tun extract. The spire of such malt, excited by heat in the presence of moisture, rushes out through the end of the corns, and eats up the kernels, while the skin of the grain becomes coated so with sugar that it will adhere to the hands and clothes of the workmen; this likewise is at the expense of the kernel, which, by its own moisture, and the kiln heat, is getting mashed before its time, some-

times distinctly forming acid. All this indicates the need of plenty of floor space, and more time, than maltsters now indulge in. Two hundred feet or upwards, for every quarter wetted on the fourth day circle, is wanted to make a roomy house, and the house should be built in the proportion of 40 feet in breadth to 100 feet in length.

DRYING AND CURING.

"Beer is made on the kiln" was a trite saying among the elder brewers, but its force has been dissipated, and is not now always accepted by the youthful brewer, nor quite felt by the aged one. The style of kiln is all-important. The arched-in and furnaced kiln is the only safe one, while the open-chambered and open-choffered kiln is the worst; and it is strange to see how, forgetful of the early experiences of the trade, brewers have allowed these malformations to grow. If their introduction was due to the desire to have pale malt for pale ales, the hope has been egregiously disappointed, for from the pale ill-conditioned malts, from such kilns, comes one form of red beer, and from the scorched, *yet uncured,* malts off the same kilns, comes the other redness, with its burned and intolerable taste into the bargain. These kilns are a mistake, and apart from his general experience of them, the author will give two striking instances of the danger of their existence.

Once visiting a brewery where the brews had been for a long time bad, he found one of these malconstructions, and a state of things of a most anomalous description. In the middle of the floor; the furnace, loaded with what seemed a ton of live fuel, and round the walls, four windows pouring in cold air. The fuel was sufficient for five or six times the quantity of malt under operation, and, but for the windows and the wind, would have burnt it black in a quarter of an hour. The state of things was shortly this—an uncalled-for

quantity of fuel was being used, but kept in subordination by an uncalled-for quantity of cold air, while, the uncalled-for quantity of cold air was being heated by the uncalled-for quantity of fuel. The kiln was twice the height necessary for curing malt, the draught was fit for a winnowing-house, and so the fuel was being thrown away, and the malt wasted. Shutting up the windows entirely, reducing the size of the furnace, and letting in air under control at a lower level, and giving more time, amended things so that the beer afterwards passed muster in the market.

The other case is that of a brewer well-known in his day for the superior quality of his pale ale, and his success in business. His success in business, however, demanded increased premises; among the increased premises was a huge new kiln, by the men of the day considered to be of most approved fashion. The beer got bad, would not fine, was milky, would sour. Water was blamed, new wells were dug, everything was blamed for a time except the fashionable kiln, but it was the fashionable kiln which was at fault nevertheless; aggravated by the negligent habit of allowing the malt to lie ungathered on it after being dried, without fire, until such time as suited other conveniences to gather it, and take it off. Here, too, some general instructions in the use of such a dangerous form of kiln brought about an amended and marketable state of things.

Malt may be dried, and cured too, on almost any kiln if the principles involved in the matter be thoroughly understood. It should be laid on the kiln thickly or thinly, according to the strength of its draught; thick when the draught

is strong, and thin when the draught is weak. Malt cannot be dried and cured in less than 3 full days (but if twice 3 days can be afforded it, so much the better), and the kiln should be so constructed, or the thickness of the malt so proportioned, as to gain this end. One kiln will make good malt with only 6 inches of depth on it, while another, with a stronger draught, will require to be covered to a thickness of 18 inches to prevent the gases from flying away without taking effect. The regulation of the draught by the thickness of the load is especially a necessity of the open-chambered kilns, because it is almost the only means by which such kilns can be regulated to produce decent brewing malt.

This theory agrees with the well-known fact that when malt is placed thick on a kiln, the drying becomes slow from the draught being impeded, and the malt is always richer in flavour than the same malt would be if dried off thinly, as it sometimes is, at two operations. It bears likewise on the peculiarity of brick floored kilns, in which the perforated area is much smaller than in hair or wire cloth, or even iron plates. Brick kilns, even when moderately laden, draw indifferently, and dry principally from surface radiation. The leading principle in all these, however, is, that the slow draught compels a stratum of heated gases to float thickly below the kiln floor which, with a greater draught, would be carried through the malt with perhaps a detrimental quantity of cold air. A strong draught is likewise an unequal draught, and the heat may pass all through a small part of the kiln area, leaving the remaining space to the action of the cold

air only. An impeded draught compels the heated gases to accumulate in a thick stratum, and spread out below the floor of the kiln; this stratum keeps the cold air down until it becomes heated, and shares in a mixture of the fuel gases emanating from the furnace. If cold air be admitted to a kiln, it ought to come in below the level of the furnace.

A strong-draughted kiln is always cold above the malt, as the heat, as soon as it gets through, dashes out at the kiln-head, and so this heat, which, if retained by a slow draught, would dry and cure the malt, is wastefully thrown away.

With the close-arched kiln, the regulating power is complete, quite independently of the thickness or thinness of the malt on the plates overhead; with these kilns the air must pass either through the furnace, or by the controllable air vents placed along side of it, to proportion the common air to the heat and quantity of the fuel gases passing through the malt, and regulate the temperature from the beginning of the drying to the end of the curing processes.

Before a kiln floor is charged with malt, care should be taken to have the fire kindled and the smoke away, and the fire ought to be kept bright from the beginning to the end of the charge. After malt is laid on, it ought to be turned over to equalize and loosen it from the effects of the treading it usually gets at this time. Kilns are generally charged in the forenoon, after the morning's labour on the floors is over, and they ought to be turned after dinner to check acrospiring and incipient browning, and at night again after the floors of the malt-house are turned. After this two turns a day

are enough. The kiln temperature at the end of the first 24 hours should have risen to 100° or 120° Fahrenheit only, as a sudden rise of temperature in the moist state causes browning in the heart of the corn. If a three days' routine is imperative, the next 24 hours should show a rise to from 150° to 160° at which it should be kept until near the discharging time, when it may rise to 170° getting an extra turn, however, to prevent browning and loss of flavour, and mix in the heat before taking off. If four days can be allowed for the malt on the kiln, a gradual rise on the third day to 160° would be better, and the fourth day to finish and discharge. There is no harm in the old practice of gathering or heaping the kilns for a night, but great care must be taken to shut up every crevice by which the natural air may find its way in to decure the contents of the kiln. With all air shut out, and a small clear fire left to fill the house with its gaseous products, the practice is safe, but not otherwise, as the kiln improperly used is as good a moistening apparatus as it is a desiccating one, and the advice given by some writers, to cool malt in the kiln, is wild.

To return to the regulation of the air supply. The air vents of an arched kiln, or the main door of an open kiln, should be left open until the malt has had a turn or two, to take off the steam; after this a gradual shutting out of the natural air, and dependence on the products of combustion ought to be established, so that drying and curing should go on simultaneously. Many of the old kilns dried through the furnace only, and so were supplied with little else than the products of the furnace. These kilns were slow, but in tracing

the connection betwixt kilns and beers, the author has always found the best beer made from the worst drawing kilns, and especially from them came what were called "Lousy" beers. With the open-chambered kilns curing is extremely difficult, and the brewers who use them now are driven to semi-roast their malt, as a substitute for curing, and to this half-roasting, at temperatures of 180° to 200°, is to be attributed the vile flavours of some beers, since the brewers have *consented* to dry their malt in preference to having red or sour beers. They dry and burn, however, instead of curing, and are out of the frying-pan into the fire: as what they get in keeping quality they lose in flavour. A pale malt kiln wants about 25 square feet to the quarter of malt.

Amber malt is best made by half-drying it pale up to say 24 hours, and ambering with still a little moisture in it. From this stage three or four turns over a fire stimulated with clumps of dry beach or other hard wood, with the kiln temperature rising to 250° or so, will finish it. Half the charge for amber, as compared with a pale malt charge, is sufficient for the workmen to deal with. As it is impossible to have every corn of a large kiln equally hot and equally brown, the kilns of amber malt are the better of being heaped on the kiln a few hours before taking off, to equalize the condition of the corns. The superheating of this malt at half dryness allows it to finish as free, and at a bulk about equal to that of pale malt, otherwise it is hard, contracted, and shrivelled in appearance. The keeping quality of beer made of the coloured malts is supposed to depend on the change of their constituents into gum or

caramelized products, rather than by fixing them in their simple state by the sulphurous gases of the incandescent coke, as in pale malt. In making amber malt, as here described, the coke is not withdrawn from the furnace, but only helped with the wood, and so the malt has the advantage of both processes.

Blown malt! brown in England, is dried in about two hours, with light split hard wood, beech or otherwise, sometimes with brushwood. The kiln floor is of wire-cloth and comparatively small, an area of 200 feet or thereby, with three or so quarters, being found sufficient for the maltman to turn. The malt is laid on very thin, not more than about 3 inches in thickness. The drying is slow for half an hour, to take off part of the moisture, as the corns burst and the malt is disfigured with moisture in excess. After one or two turns, however, the draught is allowed full play, and the malt being turned every 15 minutes, the browning is completed in about an hour more, the temperature having risen to about 300°. When the colour is correct the fire is allowed to slacken, and the malt gets a turn or two more to take off the sweat with which it is covered; after this it is heaped and taken off. Care is necessary as to temperature in discharging such malt, as over 200° Fah. it will readily fire if put in bins. At this stage the sale maltster secures himself against fire by watering and turning it before laying it aside. This article ought to be dropped out of the category of malts. It is not wanted, the amber and black fulfilling all the necessities of porter making. The author has paid particular attention to this malt, as to its keeping powers in porter, and although he

made it himself in the most approved and honest fashion, found it far inferior to amber.

Black Roasted or Patent Malt is a specialty in its manufacture, and hardly comes under the cognizance of the author, as the brewer buys it very much as he buys his coffee, from some celebrated maker. The best test of black malt is the amount of colour it contains; the colour being right, all else may be held to be right. It is made from second or third class barley steeped and couched in the ordinary manner, but is only about half-spired, however, and dried just so much as keep it in passage to the pans. The quality depends on the nicety of managing its temperature in the manufacture, and, like many other things, hangs much on the experience and instincts of the workman. The vapours from the pan show changes at every stage of the heat of the malt, and these, to the eye and olfactory nerves, are the principal guides for the workman; at all events they guide him to near the point when the malt requires careful watching, for there is a point where it melts into caramel, and it is at this melting point it wants to be caught and cooled with a dash of cold water, to prevent its going into cinder. When the grain is caught just within its melting point, it retains its shape and comes out a dark brown, in which state its colour has the best staying power. Over the centre, so to speak, it becomes quite black, and the corns adhere to each other with somewhat of a cindery look; within limits, however, the malt is none the worse of this, but a very slight increase and the colour decreases, and what is left is apt to drop out of the porter in keeping. The

colouring or caramelizing temperature, as it may be called, is about 500° of Fahrenheit, and the roasting is done in revolving spherical or cylindrical pans in quantities of a quarter or so at a time.

Gas drying and hot-air drying in pale malt making are propositions from those who misunderstand the wants of the brewer, and whose malts cannot be used in beer made on the British system, which has to keep over twenty-four hours. The large extract promised comes from the dissolution of ingredients which are not safe, and which, with coke or coal drying, would be fixed on the kiln.

So much has been said of the curing of malt, that it is scarcely necessary to add anything on the subject of redrying when a brew-house is not doing well; but the practical men are so stupid or lethargic, and the master men sometimes so falsely economical, that it had better be strongly put that "Thane" malt being, in ninety cases out of the hundred, the cause of bad beer, redrying is the cure (the only), and a never-failing cure. Some parties argue that redrying does not take away acid; perhaps so, but at all events it destroys acid ferments, and evaporates off some of the free acid; and the little free acid left does no harm to a brew. A great want with many of our brewers is that they know nothing of malting practically, being brought up to brew entirely upon purchased malts, and so in their career both they and their employers are entirely at the mercy of the sale maltsters. *(See Plates for Kiln-heat Diagrams.)*

STORING AND KEEPING.

Equally important with the curing of malt is the method of preserving its condition afterwards. The smaller brewers who make their own malt, and malt on or adjoining the brewing premises, take their malt from the kilns direct to the store-bins, and fill them one after another while the malting season lasts.

Bins generally occupy the depth of a flat of a building, and are filled from above, the upper floor serving to cover the bins below. Some have their bins open on the top, and others merely fill up rooms, large or small, with it.

Close boxes are generally preferred by parties interested, and if filled to the top with hot malt, and hermetically sealed, they are right enough. It is seldom, however, that they are so close that moisture will not get in, and be absorbed by the upper strata of malt. In the case of close boxes the upper strata cannot be skimmed off, and so it appears to the author that the bins are better to be left uncovered, and trust to a cover of commings, gathering these off, bin after bin, as their contents are wanted for use. If the commings do not contain all the moisture accumulated on the bin tops, as much malt should be skimmed off and laid aside to redry as will make matters safe.

Bins ought to be proportioned to about a week's consumption of the brew-house, as this is fully as long as malt can be exposed in such a climate as ours without losing

quality, and necessitating skimming. Malt looses curative matter from the moment the bins are opened, but reference is made to safe brewing limits. Of course, in long rooms with the malt open on the top, skimming may go on from day to day as the malt is abstracted; and there cannot be a better method of storing, proper skimming being attended to.

The only plan admissible to work without skimming is that of sheet-iron boxes, or hoppers impervious to damp, and these are the proper things for the London and other breweries, where the malt used is all carried, by land or water, for considerable distances. The malt for these, if for storing, ought to be taken off the kilns hot, put in close well-dried double sacks, and sent to its destination, emptied, binned, and sealed up without delay or exposure. The worst mode of conveying malt, or hops either, is by railway (unless the companies wrap the goods up so that the air currents cannot strike the sacks or wraps), for the current promoted by the high velocity of a train goes right through sacks, and robs both malt and hops of their keeping qualities and flavours. Railed malt, unless carefully attended to, is not fit for brewing, and far less so when it has to be stored and kept for a lengthened period, as the keeping elements are likely to be all eliminated even before it comes to hand.

For a number of years back the London brewers have been unable to make their porters remain sound so long as formerly, and, to save themselves, have to a great extent given up their large storing vats, being afraid to trust such quantities in stock as they were wont to do. The author

thinks the condition of malt-curing and transit may have changed, and that storing quantities of carried malt within the walls of a brew-house, surcharged as a brew-house area must be with damp, have one or all of them to do with the change.

To brew accurately, the malt ought to be dried by the brewer on a kiln, and by a staff of men attached to the brew-house. Let the malt be made when and where it may, it ought to be cured by the individual who is responsible for the beer. Where the maltings are convenient to the brew-house, the rule should be to use malt of a certain age—say from one to two weeks old, beginning so at the opening of the malting and brewing seasons, and so continuing unto the end of the malting season, after which, if brewing go on, the kiln must be kept going, and the surplus malt, which has accumulated in winter, should be passed over it, a two weeks' stock only of the redried malt being kept up. By this procedure with the malt, and with proper mash heats, and suitable refrigerators in the cooling rooms, a brewer will make as good work up to the point of cellaring, in summer as in winter; and, of course, summer beer is not meant for storing, but for immediate consumption.

ROLLING OR GRINDING.

The Excise law on this subject has been definite for a number of years—no grinding is allowed—brewers malt must be rolled, and with smooth-surfaced rollers too. Rolling is a simple matter, depending on a good mill with a shaker to shake off the commings and discharge the dust and impurities which may have come from the barley stage, or found their way in in the progress of making or storing. Some parties use fans attached to the mill to assist in cleansing, but wind should be kept from malt. The best cleaner is a revolving spiked shaft in the throat of the hopper, to rub off the commings, which afterwards drop through the shaker.

The rolls should be of steel, and the best speed for them is about 300 feet per minute; the shaker does very well at about 100 shakes. Rolls are generally driven at double this speed, but at high speeds the malt is knocked too much into dust. There used to be great divergence of opinion as to the fineness or coarseness of the rolled grist, and the rolling has often had to bear the blame of faulty conditions of malt, and of improper mash heats. Malt rolls ought all to be geared together with spur pinions.

Over-rolling is supposed by many to prevent the beer from fining, and many old brewers would hardly allow the rolls to touch the malt : the corns were to be cracked only, so that the water would get in to dissolve the kernel and

extract the sugar. Perhaps it is as well not to over-roll malt that has gone off in condition, or had been originally wind-dried; possibly in an over-rolled state more deleterious matter from such malts might go over to the copper, and of course improper mashing heats will not do with close crushing. Be this as it may, nothing in the logic of brewing has turned up to prove that there is anything in rolling, apart from the question of keeping the draining of the mash in view, and prevent setting. In rolling nothing should be missed, one corn in a hundred in such breweries as Guinness' or Truman's, Bass' or Allsopp's, might be a loss of seven or eight thousand pounds a year to the proprietors, so that the proper rule is to break up the smallest corn, and keep the mash-tun right by using proper mash heats. The test of rolling is to rub small samples of the grist from the rolls between the palms of the hands, when every cracked corn will at once fall to pieces, and unbroken corns are readily seen. All this, however, shows the advantage of the malt having been screened, well steeped, and carefully spired, so that it may be of a size, free and easily splintered by the rolls, and easily dealt with in the mash-tun. Where foreign barley malt is used, and now it must be used everywhere, a second set of rolls ought to be kept in requisition for it.

BEER MASHING.

"Mashing" is the process in which the malt and water are mixed together for the purpose of extracting the principle of the malt, wherewith to make the article "beer," by ulterior operations. The practical brewer ought to look on mashing as a triple rather than a single process, as, by so doing, he simplifies the logic of the operation and brings it more readily within the scope of his understanding. Water being good, and the malt and hops in a right condition, there is nothing between the manipulator and good beer but proper mash heats; these being right, it would be a difficult matter to make a bad article.

The extraction of malt for beer has an affinity of a practical if not scientific kind to the extraction of flesh for soups; and the extraction of flesh for soup, it is well known, depends on a principle the reverse of that necessary to make good boiled or roast meat. For the latter purpose meat is at once placed against a brisk fire, or plumped into boiling water. Immediate coagulation of the albumen, and closing of the pores and vesicles of the meat, and retention of the juices, is wanted in the case of roasts or boils; this is got at or near the boiling temperature of water. With soups and beers the extraction, not the retention, of the juices is the want, and therefore the malt and the flesh must be approached at a non-coagulating temperature.

Everybody knows that it is the practice to begin with

cold water to extract for soups; and the experienced brewer knows, or should know, equally well the proper heat of the water to expose his malt to, so as not to cause it to coagulate and refuse him its sweets. It is pretty well settled among brewers of experience that the heat of a pale beer mash, when all the malt and water are put together and finally mixed, ought to be 156° of Fahrenheit. It is at this heat of the first mash that the best flavoured extract is produced, and it is at this heat that the natural chemical action of saccharification takes place which gives sound vinous beer; but, as in the case of soup, this heat point must be gradually approached.

Before the thermometer came into use, signs of this natural action were looked for, in thick mashes, around the sides of the mash-tun, and when the froth was seen to press through and curl over in quantity, the elder tribe of brewers knew that they had been successful in striking the heat of their first mash. Their thinner mashes frothed all over their surfaces at the same point of temperature. First mash heats were got in those days in the same manner as that by which a butcher regulates his scalding water, viz., by superheating it and observing the period when his face is reflected on it as it cools down.

The author has said that he wishes mashing to be looked upon as a triple process, one more than seems wanting in dealing with flesh, and the digression in which he has indulged will help to make him more easily understood. The names of the processes he wishes distinguished are Saturating, Saccharifying, and Extracting. To prevent

coagulation, paste making, and setting of the "goods," he wishes to make it the rule to wet the malt at a heat that will come out in the mash-tun at say (according to strength of beer) from 148° to 152°, or several degrees below the best saccharifying point; and when the goods are thoroughly wet, to apply water at a higher suitable heat, with the internal rakes of the mash-tun revolving, until the goods are seen either with the eye or thermometer to touch the line of saccharification. After 4 or 5 hours' continuance of the saccharifying heat, he wishes to make a speciality of reducing the heat of extraction gradually from the highest point down to where the brew began, thus beginning at say 150°, and ending at the same point. There is nothing new in the system, but it will be new to get it positively and accurately carried into practice; and the result will be that, with properly prepared and properly kept malt, the work of the brew-house will be as certain and constant as working out a piece of arithmetic from day to day with the same figures.

Mashing is most simply and accurately performed by passing the malt and water through a "Steel's" or other saturator, at a heat when mixed of 148° for light, and 152° for heavy, beers. This means mixing with about $1\frac{1}{2}$ barrels of water to the quarter of malt, and finishing with a firkin to a kilderkin per quarter more of water at 190° to 195° in addition. The copper heats for the water employed in the initiatory process will average about 170°, say about 168° for the one and 172° for the other, corrected, however, by a thermometer placed in the side of the saturator, near its mouth.

A cold water attachment should be made to the hot water pipe leading to the saturator, and a thermometer screwed into it near the point of junction, to secure regulating power between the water copper and the saturator. When the mixture is in the mash-tun in this saturated condition, the copper water at 190° to 195° should without delay be let in, and the rakes set on and kept going until the goods rise, as has been already indicated, to a homogeneous heat of 156°. This method it will be seen deals with the heat of the mixed goods only, not with the heat of the water in the copper as is commonly the case.

It is imperative for both the chemical action, and the draining afterwards, that the goods should be homogeneous as to consistency and heat, and hence the necessity for an internal machine. In superheating the mash, the water in the pipe betwixt the copper and mash-tun, if long, ought to be run out, as its contents might neutralize, in a small brew, the superheating, and make the mash too cold. The rakes, too, must be kept agoing until all surplus heat be taken out of the false bottoms of the mash-tun, lest the bottom goods take up this heat and be left too hot, and become pasty, prevent draining, and give the usual evil after results. The heats laid down are for perfect malt; for imperfect malt (half-barley) lower saturating heats may be used with advantage, but imperfect malt should not be used for fine beers, as neither a sufficient nor economical extract, nor good flavour, can be got from it in a brewer's mash-tun, while the low heats necessary to saturate coarse malt is apt to induce acidity. The preceding matter on mashing relates to the

first mash, or the first mixing of the malt with the water.

The draining and the extracting of the goods ought to proceed within two hours from the completion of the mashing operation. The mash is sometimes tapped by one, but it ought to be drained by three or more cocks, placed in the bottom of the mash-tun. The draining at first must be slow, to draw off the fluid from the malt around the cocks as clear as possible; but shortly the malt thus drained will begin to act as a filter, and the draining, after about twenty minutes, may go on to suit the time allowed for the process. The time allowed for the extraction of beer brewing is about six hours, but two hours being given for the repose of the first mash, four hours only are left for extraction.

If the extract is to be completed by repeated mashings, after the first mash is run off the cocks in the bottom of the tun should be closed, and the mash-tun recharged with hot water in such quantity as to make up the second mash of the brew, at a goods' heat of about the same as the first mash. The second mash ought to lie about an hour, and when run off, the third mash, if a third mash operation be required, should be made up at a goods' heat of 150°, and lie half or three-quarters of an hour only. The water copper heats, and quantities of water required for these two after mashes, are got by experience in dealing with the plant. The second mash will want water, however, about 175°, and the third about 165° for average sized mashes. This gives roughly a three-mash brew. As it is difficult for the brewer to

calculate his quantities accurately, it is better to keep the water short on the mash, and sparge a little at the end with tepid water to make up his copper charge.

Another plan, followed by many brewers, is to make two mashes of reasonable thickness, and sparge up the remainder of the charge, but the water for this sparge ought to let the goods drop to 150°.

A third plan, the Edinburgh mode of mashing, is to sparge on all the water after the first mash. By this method, as soon as the taps have become fine, the sparge is set agoing, and the taps and sparger go simultaneously until the extracting is finished. A rough calculation is made to make the running correspond with the time—say, if four hours be allowed and 80 barrels wanted, it means 20 barrels an hour, and so on for greater or lesser quantities.

In working the Edinburgh system many err greatly in putting on the sparging water too hot, 180° to 190° is not uncommon for some brewers to begin with, working under cover too; thus the goods always get set more or less, the brew is injured, and time has to be wasted to lift the goods and get away with the running. The extract is sure to be faulty when this is the case. Paste making ought to be avoided, and unless the mash has been made too low, and the goods have become too cold, the first sparge heat should not be over 170°, and if the mash shows heat over 156°, 160° will do. The tun covers ought to be kept off while the sparging goes on, and a thermometer or two kept in the goods so that the temperature and condition may be readily seen. Water should not lie on the top of the goods while sparging, and it

always does so if the mash has been too hot, or the sparge water set on too high. The water on the top is an indication of setting, and a warning to lower the sparge heat at once, and to shut the taps below for a time.

When the heats have been right, the goods rise freely from off the bottom of the mash-tun and float, and allow the extracting water to filter readily through. This is a thing to be aimed at, and the goods should be kept up at least 6 inches from the bottom until towards the end of the sparging. As small brews must have the same time to extract as large brews, the runnings below must of course be smaller in quantity; and so the sparge water going on above must be hotter than with large brewings, where the running is so much quicker, for the small quantity of water falling from the sparger will cool much more in proportion than the large quantity falling through the same space.

After a mash has been maintained with the sparger at its proper temperature, 156°, for about $2\frac{1}{2}$ hours, the water ought to be lowered at one step 20° or 30°, so as to take the action of the high heat off the goods, and bring them down under 150° towards the end of the sparging and running.

In making strong beer, the necessity for strength will have stopped the running within the $2\frac{1}{2}$ hours' limit, and before the necessity for the lowering of the heat has arisen; so that the effect of the lowering will be felt on the after-wort only, table beer or whatever it may be, if an after-wort be required. If it be wanted to pump the tail ends of one mash over for the sparge liquor of another, all that is

required for safety is to see that the tail goods come off the one mash at the right temperature, 150° to 145°, and are heated up before going on the other by a steam coil attached to the pump to the necessary sparge heat 170°, or whatever will keep the mash at 156°.

It is here that so many brewers go off at a tangent. One brewer makes good strong beer, and cannot make good light beer, because, working without a knowledge of the necessity of lowering the heat after the expiry of the time limits of safety, the thin brew gets so much water as to be overheated, while the thick beers, finished within safe time, are right; and so the brewer who has got into the practice of working with low heats, comes out better with his long drawn thin beers, while he of the high heats does best with strong beer. Here it is, too, that the yeast is made sound or unsound, for the soundness of the beer, and that of the yeast, is a product of the same causes. The brewer's logic has been greatly strained by the yeast question, and his reasons for its failure have been a long way from the real cause. "It was worn out," "exhausted," "it required to be changed just like the seed of a field," &c. He did not see that changing, in the case of yeast, was merely changing from one hand to the other—that a cluster of breweries set down together on one spot, and using the same water and similar malt, were little else than one brewery, and that, were the brewings of the lot made under one roof, there would be no place for the change to come from. It is noticeable, however, that brewers have discovered that changes were best from heavy beers, and they had an

instinctive feeling against the yeast off pale ale or light beer. The feeling was a correct one, as with the high heats and quantity of water used, the yeast of such beer could not be trusted to do its duty. With the sparge heats properly tempered, pale ale yeast, from the large quantity of fine hops infused in the wort, is as good, if not better, than the other.*

In this essay on mashing, "tap heats," which are in every brewer's mouth, are put out of court, for, in brewing, tap heats are no safe guide; indeed, they have nothing to do with the matter on hand, any more than the heat of the water copper, which is quoted by some brewers as their mashing heat. The whole thing turns on the heat of the goods in the mash-tun, when the malt and the water have been thoroughly mixed together, and made homogeneous; the heat of saccharification; the heat at which the chemical action steps in and produces a wort which gives the vinous fermentation in the fermenting vat, and the vinous flavour in the cleansed beer. The tap heat doctrine is misleading, and no attention to it will restore a mash that has been made too hot or too cold. So, also, with the water copper heats. It is absurd in a brewer to say that he mashes at such and such a heat from his copper, thus admitting that he only guessed at his mash-tun heat, and knows nothing about it until hours after he operated upon it, when his taps are allowed to flow, and when, perhaps, all too late to amend, he learns that he has mashed too hot or too cold.

* See Section YEAST for value of after-wort.

PORTER MASHING.

The author's experience does not indicate the necessity for any great difference of heats for porter mashing other than he has given for ale: for this article he would saturate 2° lower, and make the ultimate of the first mash the same as for beer, 156°, using from this point forward the heats laid down for beer. The peculiar dry sub-acid flavour common in Irish porters, and by many liked from custom, is got by too great a range in mash heats, beginning too low and finishing too high, and getting acidity at both ends. This is all against the keeping quality of the article, and deprives it of that fullness, softness, and richness of flavour which porter brewers generally wish to be present in their brews. Like pale beer, it wants to be saturated at a point which leaves room for the absorption of its latent heat without exceeding its ultimate point of 156°.

Porter is best made from malt, two-thirds of which is well dried pale, and the other third high amber and black; roasted malt should be used to the extent of 1 bushel to every 5 to 6 barrels of finished beer. Brown or blown malts are a mere waste of grain, and have no keeping quality and little extract to induce to their use. The roasted malt goes into the mash-tun among the other malts generally, for extraction, but sometimes it is put into the wort copper and boiled with the hop. There is an alternative method, however, which, though not much practised, is worth thousands

a year to the large brewers, on account of the greater price got for the grains. This is to mash the roasted malt by itself in a small tun fitted up with a rouser and false bottom, and an inner perforated circumferential diaphragm through which to drain off the black extract. The washing out is performed by the extract from the large mush-tun—*i.e.*, of the pale and amber malts which go in under the false bottom of the small one, and, passing up through the roasted malt, drains off all round the internal circumference of the perforated diaphragm mentioned, into the boiling copper. *(See Drawing.)* Why porter is porter will be more fully shown in the section on boiling.

Mash-tuns are generally made of oak, often of cast-iron however, and sometimes of copper, placed in timber for support and the retention of heat. The false bottoms ought to be of metal, on account of the larger drainage area available with it, and are generally of cast-iron or a composition of brass. The false bottoms stand from 2 to 3 inches off the true bottom, according to size of mash-tun. The mash-tun itself should be of a capacity of 20 cylindrical feet to the quarter of malt, and be half the depth of its diameter up to 12 feet, and the very largest tuns need not be much more than 6 feet in depth. With goods of a great thickness or depth, the heats are not so manageable, from the length of time the water takes to travel through. *(See Plates for Mashing Diagrams.)*

THE UNDER-BACK.

The under-back, or intermediate vessel between the mash-tun and copper, ought to be of iron or oak outside, and have a shell of copper inside over the bottom to allow a stratum of steam to be introduced between them, to secure the temperature of the wort run into it. As the loss of heat to any considerable extent at this stage brings on acidity, it is as well to maintain the heat of the wort in the under-back over 150°. The brewers have of late years paid attention to this by one means and another, but it is well to make it a standing rule of the brew-house. Even where the wort runs direct into the copper attention is wanted, as carelessness in kindling the copper fire is sometimes indulged in. The author met with a case where the product of a brewery was sour for more than a year by inattention to this, after every other ailment had been eliminated from the malt-house and brew-house. It is easy to fall into bad ways. Experience dies off, and inexperience comes in—groping in the dark, blundering, until it gets hold of the leading strings of safety, and the pitfalls which open at every step in a brewer's career can only be avoided by a watchful humility.

BOILING.

Boiling, with our present lights, may be held to be a necessity in brewing. It has been talked of and written of as unnecessary, but no brewer seems bold enough to venture to sea without his copper. Two results are visibly obtained from boiling; one is the breaking (coagulating) of the wort, and the consequent elimination of a large quantity of albumen, which, from its changeable nature, is better out of the beer. The breaking of the wort (coagulating the albumen) is completed in about 20 minutes after beginning to boil. The flaky matter is seen easily in a glass. When the malt is low dried and unsafe, the flakes are large and like soft snow, but when the malt is new and has been well dried, they are small and powdery like snow falling through a frosty atmosphere. There is less of this deposit from the second and third boilings of a mash than from the first, although the practice is to boil longer. The extra boiling seems to be a desire to get out of the after-wort what is not in it, but which has gone away with the first boil. Let it be understood, however, that the first section of a mash cannot be boiled long with impunity, unless it is a very light brew, while the after sections may, and boiling for evaporation may be continued with safety as long as the brewer likes. The other evident result of boiling is the absorption by the beer of the flavour and bitter of the hop, and the supposed

keeping quality of which it is said to be possessed. Boiling (ebullition), however, is not essential for either the elimination of the albumen or the extraction of the hop, as these are simply questions of exposure to certain high temperatures. With low dried malts a heat below the boiling temperature of water will throw down the albumen of pale malt, and a heat either higher or lower will tell on the hop, making, however, slight differences of flavour with the different heats applied to it. If the temperature of ebullition serves the two purposes named, the ebullition comes in serviceably for the purpose of evaporation. A copper can easily be made to evaporate 15 per cent. of the water off the the beer while the albumen and hop are being dealt with, and this boiling-in allows of an equivalent of water being used in the mash-tun to extract the malt. The boiled up strength is of course left behind, and adds additional gravity to the contents of the copper. The time of boiling runs about 2 hours on an average; but 3 hours are sometimes allowed for export beers, where a great mass of hop has to be boiled down in a single copper. For heavy beers, again, say about 100° of specific gravity, 1 to $1\frac{1}{2}$ hours are sufficient, as the great density of such wort increases pressure and fetches up the copper heat so much that it causes the pale wort to brown, and get too portery tasted and dark for the article sought; besides, the discoloration shows that the time and heat has been sufficient for coagulation. It is to be noted that coagulation and discoloration will take place in strong wort in comparatively shallow depths, 4 feet or so in some coppers, so that coppers ought

to widen for strong, and contract for light beers. *(See Drawings and description.)*

The heavy beers have, or should have, always a boil of light beer of some kind after them to work up the mash-tun products and take from the hop, and utilise, its half-extracted bitter, and recover from it likewise the strong wort which it had absorbed in the first boil. The method of working with repeated boilings and returns is highly economical, and three boilings and returns of hop is common in the porter trade. Not more than double boils of hop, however, are supposed to be safe in beer brewing. Many houses will not go beyond one boil with their hop, but share the quantity told off to suit the malt amongst the boils of the mash extract to which they belong, the hop being sent to the press afterwards for such additional extraction as it affords.

The author believes that a needless waste of money goes on in the Burton breweries from the refusal to reboil the hop. The hop itself is worth at least 20 per cent. to reboil in a thin wort, and this, with the rich wort with which it is often charged, if returned to the copper and recovered, means a saving of something like £30,000 a year for large houses. A method of reboiling the hop without the risk of air exposure is ventured upon in the plates.

The bad habit of working with high tail heats has had effects which have told against the hop in the argument for reboiling; for, even when the malt is right and a single boiling only taken, the unsound product of the long-continued heat in the mash-tun acts deleteriously upon the

hop in the copper, and extracts from it the coarse astringency complained of in beer. The stronger the hop the worse the effect.

Pretty much of all that is known in boiling by brewers is ebullition. They know that water boils at 212° of Fahrenheit, but the questions of variations of temperature from barometric movements, from shapes of copper, from depths of copper, from close and open coppers, have not yet attracted their attention. These, in fact, are questions fitter for the engineer or the chemist than the brewer, and yet there are nice problems affecting his interests involved in them.

To illustrate the question of copper heats, the old porter problem will make as good a text as any other to discourse upon; for, after all the time spent and the discussions entered upon to have it solved, it is merely a question of copper heat after all.

The author can look back over nearly 50 years, and remembers the discussions constantly going on as to the why and the wherefore of the London porter flavour. He remembers the beautiful malts, amber and blown, made to perfect the style of the article in the provinces; the colouring with caramel to keep down the burnt taste of such malts, the Spanish juice that was used, and the flavouring and bittering materials without end. The old brewers were regular druggists, and while they had and did use good malt and hops, they looked on these as only the raw material of their trade — the ornate portions, the bouquets and bitters, must come from the drug shop. Yet there were instinctive glimmerings towards the state of

the case in many minds. The idea that manufacturing in large quantities had something to do with the London flavours made many provincial brewers set up large vats, in imitation of the Whitbreads and Barclays of the day, in hopes of bringing about the desideratum—"the London flavour," and the "brown head." The large vats did not give the flavour, however, or fetch the trade, so the vats were taken down and the disappointment submitted to. But how near to the right point was the large quantity idea will be understood when it is shown that, so far as London was concerned, it was really a question of large quantities, though not in the stock vats or fermenting tuns, but in the coppers, and then only a question of quantity by chance, for the brewers were innocent of any knowledge in the matter. Here the temperature was brought up accidentally to the porter point from the boiling depth necessitated by the large demands of business, by the feet pressure and its attendant thermometrical temperature. A column of 2 feet 3 inches equals, with water, 1 lb. of pressure and about 2 degrees of heat; so a depth of, say 12 feet of boiling pressure, gives 6 or 8 degrees over the heat of an ordinary beer copper. The heat of a copper is influenced by various causes. The effect of perpendicular depth must be evident to any person who has it pointed out to him. Other things are not so evident. A copper with complete freedom to the currents of ebullition, for instance, keeps cooler than one where the upward and downward currents come in contact. And so the wide bulging copper, where the boil goes up the centre and has plenty of space to go down the circumference, is the copper

for beer; while a deep copper, with almost perpendicular sides, by contracting the circulating space, and leaving little room for the descending currents, is best for porter. The slightest impediment to circulation increases heat, for the descending current being impeded, the wort at the bottom of the copper loses solidity, becomes frothy, and losing thus its power of conduction, allows the copper bottom and flues to reach heats which, even without the action of direct pressure, renders such a copper unsuitable for ale, and makes it fit to convert the constituents of dark malts into fair porter. Some length of time ago a London firm experimented with a boiling vessel with steam tubes in the bottom, and a false bottom above the tubes at some distance, to keep the hop out of contact and serve as a drainer for it. As might have been foreseen, there was no circulation through the false bottom, and the wort below was burned red at once, the wort above the false bottom remaining comparatively cold. And so with regard to another experiment known to the author, one with the movable cone fitting almost close round the sides of the copper, and with the apex lengthened upwards by an 18-inch pipe, 2 feet long. The wort, checked in its circulation, endeavoured to leap, as it were, the 2 feet; but in effecting this, not having a ready supply down the outside of the cone, got so high in temperature as in a short time to quite redden it.

In Edinburgh the coppers are much wider than they are deep, while in the west and north of England they are deeper than they are wide. In Liverpool, for instance, all the beer made is copper-tasted. It is from the copper heat

that the Liverpool beer takes its peculiar flavour, the same flavour that is to be found in whiskies when the wash-still is too deep and perpendicular in its sides. The Liverpool coppers are nearly hot enough for porter, and it is a nice question how far the great heat is beneficial to their beers. The Liverpool water is foul and deficient in brewing constituents, and there can be no doubt that if the malt used in that town was properly cured and dried to the borders of amber, to answer to the converting power of the coppers, the coppers as they are constructed would be beneficial, but without the preparation in the malt the copper is useless as a corrective.

The author has experimented and observed extensively to see if the extra heats in the copper give additional keeping quality to black or pale beers, and he is completely satisfied that the copper is helpless unless the malt has been cured and heated to correspond with the temperatures of the coppers. The narrow coppers are very troublesome and wasteful, as the contents are constantly being forced over their lips by the want of space for the upward and downward currents. In Edinburgh, and elsewhere as well, it was common at one time to use the hollow cones alluded to suspended in the copper, apex upwards, to direct the upward boiling current to the centre of the copper, and prevent it mixing with the descending current and so boiling over. These are now generally abandoned, as the contraction, if there was much boiling force, increased the heat, and gave more or less colour to the beers, particularly the strong beers; and it was to the strong sweet beers the cones were

principally applied, as the hop of the bitter beer, floating on the surface of the wort in such quantities as is used, acts as a preventative to copper frothing and boiling over, and renders the cone unnecessary.

Edinburgh and Liverpool are mentioned as at the extremes of copper shapes, but any person has only to cast his memory back over what he has seen to find that coppers are of every kind, from the shape of a gun barrel to that of a washing-tub. In one of the largest breweries in the north of England the author saw, some years ago, a half dozen of open coppers set up to boil pale beer. They were handsomely got up, and in keeping with other belongings to a most orderly establishment, but so narrow were they that, to keep them from blowing over their contents, they had in each, not one cone only, but two, one over the mouth of the other in a most ridiculous fashion. The boil in these coppers and all suchlike vessels must be a mere fry, and the imboil very feeble and worthless for evaporation and the necessary increase of gravity. Whether the conditions of this brew-house were from design or chance would be worth knowing; for here, as in Liverpool, the coppers would allow of the use of a very high dried and keeping malt. Seeing that the water was to some extent a manufactured one, this would have added greatly to the commercial safety of the concern.

Notwithstanding the brewing skill in Burton, and the necessity for free-going coppers, some of the brewers there have set up perpendicular-sided frothy things. The brewers know that colour can be got from the copper, and so, instead of boiling with coppers of a size proportionable to their

mash-tuns, they make them small and multiply their numbers to avoid the colour which they are afraid of getting from a large copper; but they are sometimes to be found working with small bad coppers, while they avoid large good ones. The London people have been forced into open coppers for beer, as the large dome coppers they had stumbled into for porter destroys the beer flavour. But here the straight-sided copper has got in somehow, and the making of pale beer was for a long time, if not yet, to the London brewers a puzzle.

That the introduction of the dome is the result of accident is known to the author in several ways. A celebrated London practical brewer, recently dead, was wont, some 20 or 30 years ago, to take fees for giving the provincials the cue to get the porter flavour, and he never even hinted at the copper. The gentleman was of the most upright character, and his recipe was only glauber salts—"sulphate of soda." Another case is that of a scientific gentleman of good experience in a London stout brewery, who asked the author, some 10 or 15 years ago, the question, "Why could he not get porter wort to break up (to coagulate) in his laboratory experiments as he got ale wort to do?" It was a secret, but he was told, "because porter wort is not ale wort, and the extracts must be exposed to temperatures correlated in some way with that of the heats at which the malts being used were dried on the kiln." Another proof is that all the London brewers do not make good porter, and one brewer at one time, a friend, and noted for scientific attainments, made the worst porter in his day, although his

pale beers were good enough. He boiled with steam in a comparatively shallow vessel. It is scarcely needful to recall the lost fame of a great London house of the last century, but a look at the boiling apparatus of the concern reveals the reason—open wooden boiling squares, and copper tubes, and steam wherewith to boil the extract of ambered, browned, and roasted malts, tell, like the others, a tale of general ignorance. Many provincials at various times have made good porter, but as the power to do so came by accident, so by one accident or another it died away. The fine quality of the London, and latterly of the Dublin, goods attracted the respectable consumer everywhere, and the local brewer was restricted either to a third class article, or made to keep by his pale beers.

As these remarks on boiling in general take up pretty well the question and let out the secret of black beers, the author thinks there is little more to be said about them. A slight repetition may simplify the matter, however, and he shortly states that porter must be boiled at a heat of 225° to 230° Fahrenheit, and that this heat can be got in a straight-ish-sided copper boiled with a good fire, by boiling at a charge depth of 12 feet, or with a pressure on even a shallow or small dome copper of 4 or 5 lbs., got by a simple safety valve arrangement. Dome coppers ought to have a vacuum valve to guard against collapse, and are all the better of a pressure gauge to check the safety valve. Porter, as has already been said, can best be made with two-thirds pale, and one-third amber and black, the pale *well* dried, and all well kept, with one bushel of best black malt to each 5 or 6

barrels of finished extract. As the malt is full of keeping quality, hop is not a matter of so much importance, in home sale porters at least, as for pale ale. With porter—whatever may be done with ales—two boils should be made from each mash, and the hops returned *in toto* for re-boiling. If running porters be made in a pale ale brewery, a return of the pale ale hops may be taken with some new to mix. Porter is none the worse, however, of good treatment. It must have the best of malt, and is all the better of good hop.

The author has seen no reason to doubt the suitability of steam boiling for brewers' purposes. Yet, it is difficult to apply conveniently, on account of the hops, unless by using the somewhat costly double-cased copper, which requires tubular assistance to give 50 per cent. or so of steam surface over that of fire surface. Some years back there was a rush made at steam boiling by a number of brewers, as a security against colour, and by others in the interest of economy; but as the colours most to be dreaded do not come from the copper, and as the economy is a false one, the fire coppers had better be adhered to until we get more light on the subject.

FALSE COLOURS.

In disquisitions on brewing it is very difficult to make clean cut sections to represent the technical divisions. There is the question of colour, on which something is required to be said, and which may be properly discussed equally under the heads of malt drying or wort boiling, as they are both mixed up with it. Fermentation is often blamed as a cause of colour; but this is a mistake, for colour is a product of either kiln or copper. Colour comes from the kiln in two ways. One is overheating, and putting colour into the malt mechanically, so to speak. The other source is that of under-drying and under-curing, and throwing off malt in a condition to decompose readily and enter into new chemical combinations. The first colour appears in the mash-tun, and all through the process to the finished beer, in proportion to the exact amount taken up on the kiln. The other colour—the raw malt colour—comes out in the fermenting tun under the influence of the conditions there presented. The cause of this colour was known a hundred years ago, but the knowledge and the means of prevention have never been consolidated into brewing practice, for the evil still crops up now and again to mystify the brewer, and rob him of the reward of his labours. The third cause of colour is the copper; but as regards pale ale beers these are now, with the exception of the Burton, made of such low specific gravity—the principal part of them being brewed about 50°—that *they* cannot

readily take injury from this cause, if made in one or two boils. With stronger beers, or where several coppers are charged from one mash—the first necessarily strong—coppers must have a free circulation, so as to be sure against such a contingency. It may be noticed that a fourth cause of colour is suspected by the Burton brewers, viz., from keeping the wort in the under-back or hop-back at a temperature from 160° to 170° *for any lengthened period.*

ROPINESS.

This form of abnormalism is a jellyfying of the beer to about the average consistency of treacle, but of a much tougher or more viscid character, and is just worth mentioning here as a warning against unlimited heat fluctuations. The rope was wont to appear in both strong beer and porter, but more often in porter, as the peculiar condition of porter malt tempted to the use of excessively low heats in the first mash, where it is evident rope took its rise. Low mash heats may be taken as a principal cause, but it seems to have been brought sometimes on by mashes being neglected and allowed to stand until the temperature became low enough to induce it. A predisposing cause too seems to have been low class malts, or a mixing of raw grain into the mash; and all of these are active in providing what seems to be the elements of rope, viz., an excess of dextrine and lactic acid.

Ropy beer has an alliance with an old article of human food called "Sowans," which in its turn was a product of steeped mill seeds, the inner husk of the oat. The seeds were steeped with cold water for some days, or until a sub-acidity set in, when both the seeds and their menstruum were put into a sieve and strained and washed. The seeds or husky portion being thrown away, and the fluid portion boiled until it arrived at the coagulating point. The preparations of Indian Corn flour, used as jellies now at the

tables of the rich, are a counterpart to the mess alluded to (formerly a diet of the poor). The flour being so manufactured that when diluted with milk or water, and heated to the boiling point, it goes into a jelly the same as the other.

The ropy beer—malt sowans, originally unsound—if it did not rope from the mash-tun, had only to wait until it accumulated sufficient acid to thicken and go into the viscous state.

Ropiness went and came with the seasons, going off in winter, and returning with the summer if kept over until the influence of the season sent it back to its old condition. Ropiness is now seldom seen, and its absence proves that notwithstanding the errors still committed in brewing, we have been drawing our practice within such limits as to exclude some of our worst failings. The cure employed for ropy beer was burnt oyster shells, pounded and roused into it with hot hop saturated among strong wort in the copper, to take off acidity sufficiently to permit of its being mixed up, and sold off, with fresh porter.

HOPS AND HOPPING.

The finest hop in the world is grown in Kent, around Canterbury and Maidstone as centres, and of these the East Kent is the best, considering both strength and delicacy. The next best in England are the Farnham and Worcesters. The latter have a fine musty aroma about them, and being less astringent than any other hop when new, are bought up for use at the beginning of the season for early brewings, and raw hopping. The best Continental hop is the Holidau; and of the Americans the Californians are the best, rubbing down with the richness of an East Kent. Hop is known best by its colour, a light straw yellow, by its oleaginousness when rubbed down: its aroma, and its fullness of seed, and exuded crystallized oils, like pollen on the body of the bee, seen when the buds are torn asunder lengthwise. The tough leathery hop of the Belgium type, and the light chaffy seedless immature hops, the outlying growths of all countries, constitute the inferior and cheap hops on the market, and are used new, or as old olds in running beers of all descriptions, dark or pale. Purchasers should have Cattley, Gridley, & Co.'s Treatise on the Hops of Kent, printed by J. Y. Knight & Co., 5 Eastcheap, City, London.

As long as a sound quality of hop and well cured is used, the country or county of growth matters nothing for keeping, and little for flavour. All beers, if kept for a few

months, get from age a general tone in which the hop blends away in the malt, and peculiarities of hop flavour are lost. Beer gets less of its flavour from hop than is supposed. The author has already laid stress on the effect of malt in giving flavour from the multitudinous conditions in which it is brought up to the point of contact with the mash water. Its barley flavour, its kiln flavour, all the flavours of all its varying conditions got in drying and storing, and even its mash flavour. The effects of these conditions on the wort, and then the effect of the defective wort on the hop when undergoing boiling, have all to be considered before the hop is either praised or blamed. Of course a weakly delicate hop is an advantage where brewers insist in making unsound wort, just as brewers benefit by the use of light foreign barleys when they persist in refusing kiln hours of sufficient length to dry the heavy barleys of home growth. Nor must it be forgotten that the hop itself must be sound—must have been properly cured and kept in close dry rooms, and ought not to have been exposed to wind draughts, or long railway journeys. It is a question how much of the bitter quality—the tannin of the hop—has to do with the keeping of beers, and whether its kiln treatment is not of as much importance as its native principle. At all events, the outcry against sulphur in hop curing has died off, and the question of the sulphuring of the bine is held in abeyance. Bine sulphuring, however, is a proof of deterioration in the growth quality of the hop, and must be discussed under a different category from the act and effect of curing.

In the hopping of beers a range of quantity so great

as from 4 to 24 lbs. per quarter prevails in practice. Scotch export pale ale is hopped 16 to 20 lbs., and Burton 24 lbs. to the quarter. Scotch mild ale is made with 4 to 6 lbs. to the quarter, and Burton mild ale with 12 lbs. to the quarter. Scotch home pale ale is made with 10 lbs. of hop, and Burton with 20 to 24 lbs. to the quarter. Porter, generally for home sale and early running, is made with 8 or 10 lbs. of hops, according to quality; and for export, with 12 to 14 lbs. of good quality to the quarter. Stout (home) is hopped with 12 to 14 lbs., and export 16 to 18 lbs. to the quarter. Porter and stout hop is, as already stated, always re-boiled.

In hopping down, or raw hopping the beer in cask, the allowance universally is 1 lb. to the barrel for home sale, and generally 2 lbs. to the hogshead for export beers, and the finest new hop is usually taken for the purpose—more delicate for home, and more strong for export. Vatted ales are always hopped down; stouts only sometimes, according to the practice of the establishment. In introducing the new hop at the beginning of the season, it is taken in quantities to suit the stock on hand of yearlings or olds. If the stock is right, for keeping beers they ought to be mixed in proportion over the brewing months, say one-sixth new for October, two-sixths for November, three-sixths for December, four-sixths for January, five-sixths for February, and entirely new for March, April, May, and forward; but a smaller quantity of new hop will do for home and running beers. Older hop should be mixed off in the mild beers. The new

beers of Burton, be it observed, are always nauseous from excess of new hop, which seems to be thrust into both copper and cask to correct stale malt. This is a great mistake, as the re-drying of the malt would secure the object much better and save the beer from being poisoned and objected to. The Bavarians use only 3 or 4 lbs. to the quarter.

COOLING.

Until recently, beer wort was cooled on cooling floors—flats of buildings floored and flanged round to a depth of 6 inches or so. When well made these floors were of oak, teak, or cast-iron; latterly copper has been used. It were well that coolers, if used, should be of metal of some kind, as the absorption from timber is very great. The loss of beer on the old coolers from this cause, and the waste by fanning, was quite equal to 5 per cent. of the net produce of a brew. So late as 40 to 50 years ago the wort was allowed to lie until it cooled by evaporation and radiation, and in summer it lay generally until next morning, and was taken down often with the sun shining upon it. Fanners, or flighters, as they were called in Scotland, came generally into use about the period mentioned, and some relief as to time was got. These were the days of "foxy" beer, a disease which gave brewers a great deal of trouble, and which generally stuck to them all through summer if it got in. "Fox" seems to have been a product of the (fungus) fermentation of the timber of the coolers. Beer got into another form of disease in those days, becoming what brewers called "blinked." This was supposed to come from the sun's rays, or from an excited electrical state of the atmosphere. These diseases imbued their special characters into the fermentation, and made the beer bad both to the taste and look. At the period mentioned brewers began

their labours at 2 or 3 in the morning, mashing and boiling, and cooling away at the same brew until 8 or 10 o'clock in the evening, if in winter; and to 6 or 8 the next morning in summer. The refrigerator, which has reached a workable condition now, permits of a brew being carried through within the moderate limits of from 6 a.m. to 6 p.m., be it summer or winter, and so "Fox" and "Blink" both have been banished from the brew-house.

Great variety of opinions have been held on the cooling question—coolers *versus* refrigerators—and while experienced brewers have been putting in refrigerators in search of sound beer, others, inexperienced no doubt, have been extending or going back on their coolers for the same reason. Some believe that the very touch of the atmosphere will hurt beer, while others will have it that some exposure is an absolute necessity to have good beer. But when people are out of order they blame most unlikely things, coolers or anything else. The fact is that the beer is not the worse of exposure to the atmosphere for a time while its temperature is up, and it seems the most convenient arrangement to have, over and above the hop-back, one cooler—both hop-back and cooler fit to contain each a brew, for the convenience of successive brewings on the same day. Beyond the advantage of evaporation to help to get rid of the mashing water, there is, however, no virtue in the cooler, and the most economical and safest brewing is that with plenty of refrigerating power, so that the wort may be run right from the hop-back to the fermenting tun. This, however, means a supply of cold water double to that needed to cool from the cooler

at a temperature beginning to run at 130° or so. All these controversies among brewers arise by their minds becoming distracted over bad work, and having no fixed rule by which to correct themselves. The cure is not to be found either in coolers or refrigerators, but ninety times out of the hundred in the re-drying—re-curing—of the malt, the other ten times being the result of improper mash heats.

Beer is generally cooled as low as can be got, in summer 56° is the rule, but, with a cold tun-room, a few degrees higher in winter will do no harm, and it is of more importance to have the heavy beer wort cold, than the lighter wort. (For the reason of this, see "FERMENTATION.")

YEAST.

The author does not enter upon the theories which have been raised in regard to yeast—whether it is vegetable or animal, or a neutral product merely of the changes taking place in the conversion of the wort into alcohol and carbonic acid gas. He deals with it in its practical sense, as known and used in the brew-house.

The changeableness of yeast, as regards fermentative power, has long troubled the practical brewer. At one time it would perform all he wished from it, while at another it became quite worthless in his hands. It has not been an uncommon thing to see a whole town in a state of excitement over its yeast, and its brewers running about seeking exchanges from each other, in the hope to find for their operations the lost elixir of fermentative life. Allusion has been already made to the idea that had taken possession of the brewing mind, to the effect that yeast exhausted itself and wanted renewal, like the virus of inoculation, or like the corn seeds of a farm, which could not be used long without requiring a change from another farm or district. Whether the latter has any foundation in fact the author's experience does not enable him to declare, but he has abundant proof experimentally that the infertility of yeast is not caused by its too frequent use, but by the bad use made of the malt by the parties who have the manipulation of it in the brew-house.

Yeast is constantly on the change, even in the same brewery—the yeast of to-day is not the yeast inoculated with a week ago. The wort inoculated has thrown off its complement of yeast fourfold more than what was supplied to it; and from this additional stock must be taken the inoculating matter for the brew of to-day, and so with every succeeding brew; each gyle throws off four times as much yeast as was supplied to it, and thus there is 75 per cent. of the yeast changed with every new brew. From these considerations it must be evident that it is not yeast that requires changing in a brewery, but the material from which the yeast is produced; and if the water be faultless it must be the malt, or the hop, or the workmanship, or all of them together. The deterioration of the yeast is an old tale, and was common among early brewers as well as ourselves; and the correction in the fermenting tun of the incorrect work done in the mash-tun was quite a small science in itself. The destruction of the fermentative power in yeast, or rather in the wort, arises from the use of too high mash heats, or too long continued high mash or sparge heats. Brewers have overlooked that in the extraction or conversion of vegetable matter a lengthened period of exposure is equivalent to the use of a higher temperature, and *vice versa*, so that a heat which might be safe on a mash for a matter of 4 to 5 hours, might be quite unsafe for 5 to 6, or longer hours. It is because of this that the yeast of the strong beers has generally been right, although the yeast of the light beers—pale ale, for instance—might be wrong.

The malt of strong beers, as a rule, may be said to have an hour's less exposure to (a dangerous) heat than that of light beer, and so escapes the destructive influences the other is exposed to.

The author has often known brewers divide a brew into two gyles, so as to get yeast for future work off the strong wort, the two gyles being mixed after fermentation; and he has known a practical brewer become celebrated for his beer who kept 20 per cent. of his water out of the mash-tun, and ran it cold into the fermenting tun; how the master's profits stood in this case is a question. It is within the author's experience that table beers drawn off after strong beers, without a lowering of the heat of the sparge water, went immediately sour, while if the sparge water was lowered at once, by the time the strong wort was drawn, say from 170° to 150°, so as to fetch the mash back to 150° by the time the quantity was all drawn off, the light beer would not only outkeep the heavy beer, but be sounder than if brewed from special malt. Of course the same results take place by lowering the water heat for the long runnings required in making pale ale or other light beers, after the expiry of the time which experience has shown to be proper to change to a lower temperature. Wort, however light, brewed with attention to these remarks, will ferment readily and throw off a yeast that will induce fermentation in the strongest beer, while the resulting beer will fine and keep to perfection. Brewers labour under one of the greatest delusions in supposing that anything deleterious comes off the tail end of their runnings,

for really the back end portion, when the heat has been judiciously managed, improves the brew to which it belongs in every quality desired in beer. It fines sooner, becomes purer, better flavoured, better coloured, than even when the running is cut short at the time this portion falls in. Care and knowledge to deal with the later runnings are all-important in making good beer and sound yeast.

The rival theories of Liebig and Pasteur are open to the general student of science, but the brewer had better not become involved in them. Pasteur's discoveries proving that air-borne germs are the cause of what was supposed to be spontaneous germination, although of the highest importance in surgery and general medical practice, are of little use to the brewer. If the malt has been properly cured and brewed, the conditions of life for these air-borne creatures are not in the wort, and so the wort is safe; and if the malt has been improperly dealt with on the kiln, or has soured in the bins, or got damaged in the mash-tun, and so gives an unsound wort, it is bound to go, air or no air. And be it remembered, that the total exclusion of the atmosphere is next to impracticable on the large scale in which brewing is conducted, though an English brewer of skill and position is at present trying to work out views akin to Pasteur's; with what result remains to be seen. Fermentation has been tried both with the air excluded, and with air driven through the fermenting medium, with alike results, except, in the latter case, the waste caused by the air carrying away the wort with it in its escape. From whatever cause, if the wort comes from the mash-tun in an imperfect state,

it is idle to talk of benefit from the exclusion of air in the after processes. Pasteur's work shows yeast cells in various conditions, and were he or others turning the microscope to the cleavages or granules of fractured malt, and to the internal conditions of sound and unsound hops, they might be able to detect and check in time the causes of these abnormal conditions in yeast.

In localities where yeast cannot be got by exchange, it may be originated from a compound consisting of about 14 lbs. of grated potatoes, and a similar quantity of molasses, coarse sugar, or honey, mixed into 3 gallons of water or thereby, of a heat to make the mixture 70° to 75° Fahr. This should be set in a warm place until it ferments, and then be mixed into three times as much more fresh first wort, as it comes from the mash-tun; temperature being kept right, however. This is often got up by distillers, and is known by the name of "Bub." When a brewer is driven to the use of Bub, he ought to employ it on a small brew to raise barm for future brewings; the quantity proposed will ferment 40 or 50 barrels.

FERMENTATION.

The author makes use, but with reservation, of the term fermentation out of respect to use and wont, for with the beer brewer fermentation is only a means to an end. Of course, a brewer knows that he gets what he wishes, attenuation through fermentation, but he has no direct power over it, as he has over his malt-making and mash heats. Fermentation is an action independent of him, proceeds independently of him, and gives results quite regardless of his endeavours to control it. To listen to the language of the trade, one would be led to believe that there were many kinds of fermentation at its disposal; but what it calls methods of fermentation are merely mechanical arrangements to carry through the processes of attenuation and cleansing. The brewer has only one fermentation open to him, and that is the product of the malt and of its condition when brought to the mash-tun side, of the water heat applied to it, and the heat of the mash when the malt and water are homogeneously mixed together. The brewer's fermentation is limited to the condition of his wort; and while he would no doubt benefit by a knowledge of the general subject in its scientific or philosophic bearings, he must submit to be kept meanwhile to the practical and commonplace, and rather than enter the region of discovery, try from out of the disjointed knowledge already in his hands to construct a solid and reliable base in the fermenting tun,

from which his attenuations may proceed, day by day, from beginning to end with unfailing and regular results. In the articles Malting, Mashing, and Yeast the author remarks on conditions of things pointing to this end, which he can only recapitulate here, and which stand as follow:—

Firstly—Careful malting so as to have the malt always in the same condition of freeness, and so avoid the distracting necessity of mashing one day as if on malt, and the other as if on raw grain.

Secondly—Careful curing of the malt on the kiln at the time of drying; to effect this curing, keeping the raw atmospheric air as much as possible from coming in contact with it, and storing it in suitable boxes so as to retain the curative principle acquired on the kiln.

Thirdly—To keep these boxes of a size that, when opened, will allow of their contents being used before the malt loses its curing, and goes off into the slightest decomposition—acid or putrefactive—or alternatively, to re-cure the malt throughout the summer regularly, in quantities suitable for daily mashings, a week or two before it be wanted for use; and thus have the malt, when it comes to the mash-tun, in its soundest possible condition, and fit to brew sound beer, whatever the state of the weather.

Fourthly—In mashing; to wet the malt first into a thick mash within the point of the ultimate heat, so far as to allow the variations in the heat of the malt under use to expend itself within said ultimate heat, and thus prevent the setting of the mashes, and the passing to the fermenting tun of pasty, unconverted matter, to rot and *stink* afterwards

in the beer. That this wetting process produce a homogeneous heat of 150°, and that immediately after this wetting, hotter water be turned on and the mashing rakes started, to bring the mixture up to 156°.

Fifthly—That the mash, after standing $1\frac{3}{4}$ hours, should have the sparger heat regulated to keep the goods at this 156° for from $2\frac{1}{2}$ to 3 hours from the time of setting the tap; and if the goods be not extracted by this time, that the water be lowered 20° or 30°, or more if necessary, to lower the goods in the tun to 150° by the time the extraction is finished.

Sixthly—That in mashing, time and temperature being nearly synonymous terms; what is given to heat ought to be taken off the time to which the goods are exposed: thus if in sparging, the goods heat creeps up to 158°, or say 160°, the sparge water heat should be lowered for the first half hour, and for the latter state of things a whole hour, sooner than the three hours given as the standard period of high heat exposure, so that the goods will have gradually declined to 150° at the end of the process. That if second mashes and a sparge be the method followed, the second mash heat may be 156°, like the first; but the sparging to follow ought to lower the mash towards the end gradually to 150°; and if a third or fourth must be taken, neither ought to make the goods over 150°.

The methods of fermentation—*i.e.*, apparatus for attenuation, are numerous, and so well known that the author will merely allude to them. There is the London system, the Burton system, the Yorkshire system, and

the Edinburgh system, which end all in one system—viz., apparatus for attenuation. The wort unattenuated goes in at one end of the process and comes attenuated out at the other: it has given off a large quantity of carbonic acid gas and yeast, and, in return, has become highly alcoholized. The modes of fermentation have all grown out of old domestic institutions, and the differences of the systems result from local requirements and necessities. In London the brewers manufacturing porter, and having a large demand to supply, allowed their coppers to grow not only with impunity but with advantage, and the enlargement of a brew-house was the enlargement of coppers, coolers, and fermenting tuns alike; but the point reached, where the heat of the large tuns became unmanageable, and where danger stepped in, subdivision became necessary, and hence pontoons and the necessarily complicated apparatus of attenuation and cleansing. In Burton there was the colour question, and the copper had to be kept of moderate dimensions. As already remarked, it seems not to have been known in that locality that it was not quantity in copper that reddened the beers (when it was not raw malt), but depth of copper. At all events, the coppers were kept moderate in size, and the fermenting tuns followed the coppers. Here the subdivision system has got established as a principle, in the belief that it gives peculiar flavours: and although the fermenting tuns be of a size similar to the Edinburgh tuns, 40 or 50 barrels, and controllable by refrigeration, the more costly system of subdivision is preferred. It is a question to be decided whether these

tapering-off processes by subdivision in numerous small vessels has anything to do with the softness of Burton beer. The author thinks not, and looks upon them as mere continuations of the old stillion system.

The Yorkshire system is a clumsier adaptation of the methods employed in Edinburgh, where, until lately, fermenting and cleansing was carried on in a single vessel, the heat being controlled by cold water when necessary. The Yorkshire tun is made of flagstones, and cased to allow of a stratum of water being kept in or passed all round it. It is covered over all except a manhole, and has on its top a second receptacle of stone, nearly as large as itself, to receive the yeast which works up through the manhole. The fermentation on this system goes on slowly because of the low temperature—about 64°—at which the beer is kept, and the yeast has to be pumped down among the beer several times a day to keep the fermentation alive. The low temperature and the covered tun retaining, as they do, the carbonic acid gas, give this beer its full and gassy characteristics.

The Edinburgh system is almost the same as the preceding, but cooling pipes are put round the insides of the tuns, and with similar effect on the character of the beer, when the temperature is kept low. The enlargement of the breweries, and the introduction of the pale ale trade, have modified the Edinburgh system. Instead of working at low temperatures in comparatively small tuns, the tuns are now made to contain 40 to 50 barrels. After the second day in the tun, rousing begins, and the heat is allowed to

rise as in Burton, but under the control of cooling pipes, so that the attenuation and the heat may keep pace. When the latter reaches to 74° it is discharged into a flattener, locally called a square. The squares are fitted, like the tuns, with cooling pipes. The beer, lying in them about 18 inches deep, soon loses heat and fermentative power, and depositing its yeast at the same time, is fit in 36 hours for racking into transit casks. The Burton cleansing method has been tried in Edinburgh, but the advantage, if any, is not so distinct as to invite a change to that system. The Burton brewers might benefit by using the Edinburgh system in summer. In this system the beer has to be dealt with in two vessels only, the tun and the flattener, and to these water can be readily applied, and the vessels and the beer cooled. In the Burton system the beer is very much exposed in cleansing to the atmosphere of the cleansing-room, which would require to be cooled as well as the cleansing vessels to keep matters safe. Great care is necessary in the use of fermenting tun refrigerators, as a sudden application of the cold will throw down the yeast, and bring the attenuation to a standstill. It is better to begin on the gyle early and use the cooling power gradually, until at least the attenuation sought has been reached.

The Edinburgh system, though the simplest and most economical, may be carried too far. Beer for racking fine from butts is sometimes passed through the squares, racked into the butts, and racked to go out to the consumers. When racking is a necessity, the squaring ought to be omitted, and the beer cleansed into the butts from the tun at once.

From the fact that some of the Dublin houses have changed successfully to the use of mere flatteners, and given up the subdivision system, the author thinks the use of a minute subdivision system is not a necessity of good beer. At all events, the advantages must be detracted from when the vessels have all to be racked into a settling square, and re-racked into the transit casks, as in Burton; but the quality of the Burton water permits of liberties which cannot be taken elsewhere.

An ancient method is still followed in Liverpool and some other places in England, that of sending out the beer in the cask in which it is cleansed. This system has the advantage of retaining in the cask a large quantity of the carbonic acid gas of the fermentation, and the beer is brisker and fresher, and fines better than over-racked and over-exposed beers; but the system is only for a small scale of brewing: this is what brewers mean, though they do not express it properly, by keeping "Mother" in the beer. The same principle is involved and followed in champagne making, and its effects may be remembered in the small beers, domestic and otherwise, of this country before they were pushed out of existence by the introduction of tea and coffee, Burton pale ale, wealth, and a higher style of living among the people. These beers were allowed to ferment in the bottle, and cork themselves, as it was called, by the yeast choking up and drying in the neck of the bottle; and the result was that they retained so much of the gas of fermentation as to take the breath for a time from the drinker. This quality is still desiderated in beer, and there

has been a deal of speculation as to what was its cause, and what has been the cause of its disappearance.

In search of similar effects it used to be common in Scotland to put fresh wort in excess into light porters for bottling (and table and small beers as well), so as to cause them to re-ferment, and throw a heading out of the bung-hole, for three or four days, when it blackened, settled down, and was bottled. These beers came quick in the bottle, and were brisk, but the re-fermenting seems to have been to reduce them to a regular condition, so as to be not only brisk, but of a uniform state of briskness.

The heat of attenuation is of importance. For strong mild beers, where fullness is wanted, the fermentation ought to be kept as low as possible, beginning at 56° and finishing under 66°. With hopped beers, whether pale ale or porter, a considerable heat is wanted to mellow down the excess of hop and take off its raw vegetable flavour. This heat, however, requires to be checked about 72° for ale, and for porter about 76°, and hence the necessity for subdivision vessels, flattening squares, and refrigerating.

Attenuations generally run down for mild beers to about two-fifths, and for pale ales and porters to about one-third, of the original specific gravity, and the export beers are usually attenuated to about one-fourth.

In summer working it is a mistake to seek for low attenuations, as the time lost is so much taken from the life of the beer, and the shorter the period of exposure to the fermenting heat in the hot season, the better for the beer and for the brewer.

STORING AND CELLARING.

When old beer was a want in the community, storing away for long periods in vats and large-sized casks was common; and it was a thing to boast of a year or two hence, when these beers matured fine into apple and other flavours, which are not believed in now-a-days. Vatting is going out of fashion, and has already gone entirely for ales, either for home or exportation.

In Burton, beers are stored away all in transit casks, of all sizes, from butts down to kilderkins. The storage space wanted being now so very extensive, brewers have ventured on storing out of doors, and the surplus of the winter brews is piled up many tiers high, in acres of horizontal extent in the yards and fields belonging to the various firms. Chilling or freezing in winter is held to be beneficial for the beer, on the principle enunciated by Liebig in his Bavarian theories—viz., that when fermentation is carried on at a low temperature, the changeable elements in the beer are separated from it without danger of acidity. Whether this be the case or not, beer, like frozen flesh, fowl, or fish, is safe so long as the temperature is low, and the wintery condition of the beer carries it in safety far into summer.

Like the other beers, export beer is now all kept in butts or hogsheads, for the purpose of earlier maturation, for convenience of transit, to avoid the necessity and danger of racking, and to prevent the loss accruing from large

quantities of beer going wrong, by one bad brewing getting mixed with and acting on the others, when a number of brews are put in one vessel.

Even porter brewers now are afraid of vats, and have been wearing out of them for some time past; but the necessity for this is not so clear, seeing that the high dried malts used for porter give a keeping quality of an indisputable kind; and that porter, made as it is from such malts, if properly mashed, will keep for a long time, and instead of hardening will mellow, soften, and become more delicate, after the manner of port wine, for a couple of years or more.

The causes of porter not keeping as it used to do are to be found like anything else of the beer kind in ill-cured or exposed malts, or a careless or reckless application of mashing heats. There is not the least necessity for the desertion of vats by porter brewers. They are a necessity of the trade, and a convenience to the trader. Porter requires keeping; even light porter is not generally palatable until several months of age, and vats form an economical medium for storing it away.

Store vats should only be filled in winter when the temperature can be brought down to a point not to be overcome by the heats of summer. When this cannot be done, water coils ought to be put into them, suspended from the top a short distance down, and a supply of iced water sent through to lower the temperature as much under 50° as possible. These water pipes are as great a necessity of the store vat as of the fermenting tun, and are used here and

there with known advantage. Storing in butts has long been practised in some of the London breweries, the reason assigned being the quicker maturation of the heavy porter. Now, however, from the discarding of large store vats, casks of all sizes, and with all kinds of porter, are filled and stowed away for a time; and all porters, except that for special or export bottling, goes out much newer than it was wont to be sent.

As in Burton, so in Edinburgh, Alloa, and the provincial breweries generally, the beers go all now into transit casks, get hopped down, and if not immediately wanted, are put away for a time, but re-tapped up and re-shived, and sometimes fined when going out.

Beer-racking is nearly extinct in England and Scotland, and is only followed from the necessity of supplying small family or other purchasers; and the practice is well out of the way, as such beer is always stale and complained of ere the kegs are half emptied. Parties who cannot purchase a kilderkin ought to take their beer in bottles, like their wine, from their publican or grocer.

The attempt to deal with porter without racking will prove a failure, as porter takes after the nature of port wine. Its lees are very bitter and nauseous, and the turning over of these lees when the casks are moved and sent out is sure to injure the flavour. Again, porter cannot be taken when flat, and without the head is simply intolerable. To procure this head draught porter is always (or should be) mixed when going out to the consumers with new unfermented wort, and the mixing is most conveniently done in

the racking system. This mixing matter goes technically under the name of "fillings." It is wort taken from the cooler at the same time that the fermenting vat is filled, and is put into open-ended puncheons and lightly barmed with a quart of yeast to each to prevent spontaneous fermenting until they be wanted for use. The puncheon, or whatever it be, which is first required gets extra barm, half a gallon or so, to make it chip and to fetch it up to the curling point by the time it is wanted, and so the others in their turn will get as much additional yeast on the night before they are wanted as will cause them to chip, and be ready by the time they are to be used. These fillings are the better of being taken down *not* less than twice a week, and of an average gravity, so as to suit all the varieties of porter going out.

If the fillings vessels are in underground cellars their heat will not need assistance, but in winter, if exposed, the temperature of small quantities gets so low that they will not come to a head without being pan-heated, and that as high as 64° or 66°. Some experience is required to manipulate the fillings, but with this experience it becomes quite easy to deal with them. These remarks apply to provincial brewers; but in Ireland the people will have brisk porter, and in Dublin small service vats are filled in the night with their proper quota of new and old, ready for the next day's demands. The London retailers pursue a similar practice in their cellars, and thus relieve their brewers of the trouble. Fillings are used principally for draught porter, and the allowance ranges from 10 to 20 per cent., according as the stock is new or old. The best

draught porter is made of matured, *well-attenuated firm old,* mixed with 15 or 20 per cent. of rich unfermented raw wort—the fillings alluded to.

A drawback to proper cellaring in this country, as compared with the Continent, is the want of ice, and the ice machine—the substitute for it—ought to be in every brewery, so as to give the means of lowering readily the brews while in the brewer's hands, to a point of at least comparative safety. Ice itself is not much of a necessity, and water, say at 40°, is not very costly to produce. Some special means of cooling transit casks, before going out in hot weather, ought to be adopted, as these, however good before leaving the brewery, often refuse to fine, and even when they do fine, go off into tartness.

Beers for use at the end of the season should be deposited in the cellars of the publican in spring time, before the frost has left the atmosphere. Such beer ought to lie especially aside, and the beers wanted up to say the 1st of August taken in the meantime from the brewery, after which the other should come into play. Beer deposited in a cool state, in a cool cellar with the publican, and its contents never disturbed, has great advantages over that—even though kept cool—coming from the brewer's cellar, which has to be turned over and have all its half-rotten and yeasty grounds sent through it, and then heated by a summer journey. The former may be consumed from its first fining, but the other has to fine over again, and that when in a lifeless, if not unsound, state. The same arguments apply to summer brews, of mild beer particularly;

but all beers ought to go out to the consumer when cleansed, and be used on the first fining down; for once fined in the brewery, and turned over in summer, and heated in transit, the chances are many that it will not go down again before it reaches the souring point. A great mistake is committed by brewers continuing to keep up stock in spring or summer after the heat has set in. Brewing should stop at the first appearance of heat, and the brewery remain silent until the stock on hand is totally exhausted. It is very foolish to brew in May or June a stock of beer to go out in August or September, and risk the keeping, when beers can be brewed as well at the end of summer as at the beginning of it, if the malt be in order. A thorough clearing out of the stock by the end of July by provincial brewers, and by the end of August by those of Burton, is a safe rule to look to and observe.

It is a good course in cellaring to send out the best beers first, as in waiting to get rid of indifferent brews both may be lost. In the brewing business the publican ought to be protected as far as it is possible to do, and his sales kept up, as without this the brewers would do nothing. Many brewers are reluctant to take back beer although it stands preventing sales. They seem not to be able to raise their minds beyond a present transaction, though the loss is of little consequence compared with the loss of the customer and of their own good name.

Returns ought to be packed away on coming home so as to be comeatable for examination and assorting. Much beer comes back to a brewer with which there is little the

matter; and in October, when the beer is going out quite new and raw, the returned beer (not acid) may be mixed away with advantage. What will not mix with beer should be sent to the porter brewer, or ran into the sewer at once, so that the casks may be recovered.

In regard to beer returns, it is well when a brewer has a mixed trade—one in both beer and porter—as the porter from the high dried malts worked into its manufacture, bears with old beer, particularly bitter, in considerable quantity. The ignorance on porter-making, and the bad porter made, has hitherto deprived the provincial brewers of this resource to fall back upon, and they have often to send beer to London or Dublin at six shillings a barrel, which is worth four times the money in malt and hops. It remains to be seen if these brewers will have the courage to make an honest article, out of good honest sound malt, now that the way has been pointed out to them.

FININGS.

Well-made beer does not require finings, but as every brewer has imperfections in his beer, more or less, and at one time or another; and as all are anxious to have their beers consumed as quickly as possible, finings are used and will be used. There is no use in referring to any substance but isinglass, or to recommend aught but the best of it, for, at least, the pale beers. The best solvent for isinglass is dilute tartaric acid; but as this menstruum is favourable to the existence of animalculæ, it requires to be supplemented with a quantity of sulphurous acid, the antiseptic principle of which, when mixed with the other to the extent of a quart or two to the hogshead, keeps the finings sound, and protects the beer to which it is applied from being impregnated with the seeds of destructive ferments. 4 lbs. of good isinglass dissolved in 1 lb. of tartaric and water, and the above quantity of sulphurous acid, gradually diluted as the isinglass dissolves, will make a hogshead of finings, of which a pint is enough to the barrel of beer. The smell of sulphur ought to be present always in the casks in which the finings are contained.

EXPORT BEER.

The capital involved in the export beer trade, and the risks to which that capital is exposed, render the subject of brewing sound beer one of the gravest importance. The beer trade is perhaps the most hazardous in which the mercantile community engage, for while it is exposed to all the contingencies of market fluctuations, like other trades, it has superimposed on it the dangers attendant on dealing in a perishable article. The quantity of beer now annually shipped is given at the end of the book, and it shows the trade to be a valuable resource for labour, and to be equally valuable as an investment for capital. And so whatever can be done to give the article a permanence approximating to that of other objects of commerce must assume the character of a public benefit. Little, however, can be said in aid of export beer that has not already been said in former parts of this essay in regard to home beer.

It was for long supposed that a difference of mash heats was necessary for export beers, and at one time some parties did mash higher for them than for home beers, and a beer of a pale unfermentable quality was turned out to meet these views. The views were wrong, however, as high heats, or low ones either, away from the normal brewing points, are alike bad, and produce nothing but mischief. High heats in the mash *do* fix the fermentation, but if

continued for a few consecutive brewings will silence a brewery, unless such brewings are accompanied with home or strong beers, brewed properly, to furnish yeast for the other. Such beers are fundamentally unsound, and if not brewed in the most favourable weather will sour early. Under any circumstances they will be milky, scaly beers, and seldom properly fine until the acid fermentation has gone through them, after which they drink with the flavour of thin old beer. Besides his ordinary experience, the author has seen this style of brewing exemplified on a large scale, and the effects—most disastrous—which were the issue.

Attempts to limit or fix fermentation in the mash have never succeeded, and never will succeed, without the aid of the kiln. The kiln is the place to operate for this purpose, and *skilled* attention there will always be followed with sure and good results. The greatest exporting firm in the world has established itself by its superior knowledge of kiln conditions. All the advantages of bisulphite of lime, salicylicic acid and other chemicals, used to put a good face on bad beer are found, or substituted for, on the kiln; while what is obtained on the kiln is permanent as against the evanescence of the others, which do not prevent bad beer from decomposing, but only neutralize the products of decomposition as they are thrown off, filling up the beers with neutral ingredients to be decomposed in their turn. Sulphur is sometimes used to fumigate the storage and transit casks of export beer, and when applied to pale beers this is right; but it must not be depended on to supersede,

or serve as a substitute for, the attentions required elsewhere.

Export beers are made of gravities from ·40 upwards, rising for reasons of excise drawback—fixed in 1861—in stages of ·5 at a time to ·115. The drawback begins at four shillings and threepence per barrel—four shillings for malt and threepence for hop—and increases sixpence for every additional ·5 of gravity. Seldom anything is exported so low as ·40, and the principal article made to take so low a drawback as ·45 is a light porter for the stores of the Planters in the West Indies and for a small business with Nova Scotia. Its specific gravity is always ·47, it is made (or should be) of well dried malt, one half pale, the other half being amber and black, and hopped with 12 lbs. or so of fair Bavarian or American, double boiled. It goes out in hogsheads from London, Edinburgh, and Glasgow, in small quantities, and sells from 18 to 24 dollars per hogshead, according to quality, demand, season, &c.

The real export beers begin at ·50, but this gravity is only used by what may be called outsiders, and the gravities now in vogue are ·55, ·60, and ·65. Formerly the drawbacks were set at ·41, ·54, ·68, ·81, ·95, ·108, ·122. Then the ·54 drawback was mostly aimed at, but a large quantity was shipped which took the drawback of ·68. Strong beer is not appreciated abroad any more than at home, as the gaseous refreshing quality of beer is the cause of its demand and consumption, rather than its alcoholic constituent. With the exception of a small quantity of strong beer at ·90, the gravities of the day may be put down at ·55 and ·60

for the product of the Scotch breweries, and ·60 to ·65 for those of Burton. Bottled porter, however, generally takes the ·70 drawback. These beers are all hopped to about the quantity stated in the article "Hopping," and are attenuated down 75 per cent. of the gross extract, at the end of the fermenting and cleansing operations.

Large quantities in wood to bottle abroad were wont to be exported to India (and elsewhere where labour is cheap); but although the quantity is still considerable, it has fallen greatly off, excepting, of course, the army contracts, which go all in bulk. Bottling in hot climates has been found not to answer; a fact which might have been surmised by the experience of summer bottling at home. Beer in India in good times used to sell at £8 to £10 per hogshead, and oftentimes more; but when the markets got glutted, half these sums had to be taken. And worse even happened, for when it encountered glutted markets it lay and soured, and had to be run into the sea by hundreds of hogsheads at a time. It is a mistake to suppose that—with the exception of Canada or the States—the English export trade is affected seriously by native brewing. Last year's returns, which show a great falling off, represent the shipments to beer brewing countries, such as the Australian markets, to be larger in proportion than those to other places.

The bulk trade in beer goes on in the brewing season at once direct from the cleansing vessels, and is continued out of stock through the other part of the year. The general storing in hogsheads (now in fashion) facilitates this

section of the export business, as the bulk demand can be drawn from the same stock as the bottle, and what remains at the year's end goes over for bottling.

Export brewers may draw a useful lesson from the schedules of the Indian army contracts. These stipulate for beer to be brewed after the 1st of November, and of barley malt only, well dried. No sugar or other brewing compound to be used. To be of not less than ·60 of gravity, and to have not less than 20 lbs. per quarter of the best English and Foreign hop (no Alost), mixed in suitable proportions, and to be placed in the casks for shipment not later than twenty-one days after the date of brewing. The casks have to be hand-made, of Memel or Bosnian wood, free of worm holes, strong, and steam-seasoned. These contracts touch the primary points very fairly, but give the minimum of malt and hop only to the brewer, who may increase them to the point that insures the stability of the beer and protects his character.

Beer for bottling should be kept nine to twelve months on hand before venturing to ship it even to near ports. It should be brewed from October to May, inclusive or otherwise according to weather, and it is imperative that it should undergo a *summer's heat and the autumn's fermentation in cask in this country* before bottling. The brewings of the one October are thus fully ready for the bottlings of the next October, and so on with the produce of the other months in rotation. Of course the beer cannot be kept always of one age from the variations of demand, but different beer is wanted for different markets, and it is all the better to be

about eighteen months old before crossing the "line." Stocks must be watched, so that they do not increase beyond this age. In the early days of export bottling, beer was allowed to stand for a week uncorked to get it flattened, but the practice, never a good one, has been superseded by allowing the beer to age more in the wood, and so admit of bottling and corking at the same time.

The most economical mode of bottling is to run the store hogsheads or butts off, dry to the hop, into vats containing about two days' supply, and fining it down there a week before it is wanted. These vats ought always to be well sulphured before filling, to keep the air off the beer in this its racked condition. What is said of beer (pale beer) in these remarks applies to porter, but with this difference: porter for bottling requires to be kept nearly twice as long as the other. The high-dried malts of which porter is made, causes it to remain younger (so to speak) than the other, and thus its time of ageing is considerably extended. The use of sulphur in connection with porter in the brewing or storing vessels increases this quality, and as it is neither good for the flavour nor colour of porter, it is better dispensed with.

Strong casks of the best timber ought to be used for exporting beer, whether in bulk or bottle, as the saving of a penny or two, or a shilling or two, in either case, is a poor compensation for broken bottles and leaking casks. For the bulk trade no casks but those made of Memel or Bosnian are admissible.

Casks for export, as well as home sale, are now all

steam-seasoned. They are best set on end with the steam-jet into the tap-hole; the bung-hole filled up by an old shive, with an open spile-hole in it to show the pressure of the steam. The steam should be soft and watery, to make the conditions as like those of boiling water as possible. The practice of steaming casks on their side by the bung-hole breaks innumerable bung-staves, and when steaming old casks almost every bung stave is fractured. It is a mistake, however, to steam old casks at all, as the best way to deal with the acidity which is wished to be extracted is to fill them with water, adding a handful of quicklime. A fill of lime and water for a day or two used to be the rule with new casks to complete their seasoning, but now a few hours more steam time is allowed to finish them off-hand, and five to six hours makes them quite free of wood flavour.

SUMMER BREWING.

The methods commented upon and recommended in the preceding pages show that there is little difference in brewing, *per se*, whether it be performed in summer or winter: that the difference practically felt has arisen, not from the effects of season on brewing, but from the effects of season upon brewing material. A hot season, aggravated by moisture, attacks malt and sends it off into conditions inimical to the necessities of the brewer, and makes sound beer impossible. Malt, if exposed, softens in winter as well as in summer, but in winter acidity does not set in so strongly, and so, with the generally more favourable surroundings, the effect does not produce such bad results. In winter, too, the chances of malt being used newer intervenes, and still further reduces winter risks; so that, although winter beer suffers from the same causes as summer beer, and must be to some extent deteriorated in quality, still the deterioration being not so great, and consequently not so obvious, is often thrown entirely out of the brewer's calculations. In summer, however, thane malt will not allow itself to be neglected, but asserts its right to make bad beer against either the ignorance or the obstinacy of the brewer, and the advantages of the contention are all on one side. Beer cannot be made in summer if malt has gone off; but such malt may be easily detected if put under examination, as it leaves on the palate the flavour of alum, and a feeling of astringency which remains for hours. When such is its

state it is unfit to brew—possibly the microscope might take the place of the palate in such examination.

No summer heat in this, or almost any, country exceeds our proper mash heats, and as these need not be under 150°, it cannot be in the mash-tun that summer effects come in detrimentally—the malt being right. If the under-back be fitted up to keep the wort over 150°, no harm can accrue there; and surely the copper kept up to the evaporating point may be considered safe. The hop-back and cooler are safe down to the atmospheric temperature at least, but even here, though danger meets the beer, there is little to fear, as the protective relief is at hand in the shapes of refrigerators and cold water. What applies to the safety of the beer at this stage, applies to it through its attenuation in the fermenting and cleansing stages, and the necessities are summed up in gyle refrigerating, and cool fermenting and cleansing rooms. Summer and winter brewing is similarly circumstanced, in the respect, that neither in summer nor in winter does the beer come in contact with the natural temperature. In both seasons the beer is in an artificial temperature; in winter above the outside air, and in summer below it; and as like conditions all through the arcana of nature produce like results, so will the results of summer and winter brewing be the same, if the malt has been good, and the temperatures kept in accordance with each other. These remarks go up to the point of cellaring, when, if the beer cannot be disposed of, an extension of the cooling appliances should be made to meet storing exigencies.

BAVARIAN BREWING AND FERMENTATION.

The object of the author in introducing remarks on the Bavarian system is for the purpose of corroborating his views, to the effect that fermentations are products of the *condition* of malt, and its *treatment* in the mash-tun. Liebig, and other writers on the Bavarian system, attribute the peculiarities of this beer to its "Depositing Fermentation," and they all, tacitly at least, lay the cause of this fermentation on the low degree of temperature at which it is conducted. Were there no difference from the English system in the mode of treatment of the materials which go to make up the menstruum which has to undergo fermentation, it might be possible, in the absence of experiment, to admit that cold produced such a wonderful effect; but the treatment of the goods in the mash-tun is so dissimilar that it is astonishing this dissimilarity, instead of cold, has not been accredited with the difference. But again, experience with the English system does not lead to the inference that cold will produce the depositing fermentation, as any person of experience must have crossed a fermentation not much higher than the Bavarian. The old Scotch strong ales were wont to be started at 54°, and carried through at temperatures scarcely exceeding 60°, and in winter sometimes so low that they required heating

to keep the fermentation alive; but the fermentation, however low it went, never gave indications of going into the depositing order, but rather simply, would have stopped in its action altogether.

The Bavarian fermentation ought to be called the "Decoction" fermentation, in contradistinction to that coming out of the "Infusing" mode of the treatment of malt—the "Infusing" being the English mode of treatment, and the "Decoction" the Bavarian mode. The high temperatures to which the malt is exposed in the latter system must be accredited with what praise (or blame) belongs to it. The English fermentations assume many phases, from even the slight variations of manipulation and condition which arise in the course of operations; and doubtless within the area of the decoction fermentation there are oscillatory movements of a similar character. We have boiling fermentation, hissing fermentation, pasty fermentation, the belling soap-bubble fermentation, fast and slow fermentation, and thick and thin-headed fermentations, arising from new malt, hot malt, slack malt, from high heats, low heats, etc., in the mash-tun, the causes of which have to be elucidated by careful study, but in the meantime avoided by steering close to the points indicated as safe by practical experience.

All throughout Germany the malt is "hot air dried" only; the charcoal fumes, on which the author lays such stress for curing the malt and keeping the beers, being carefully excluded from contact. The Bavarians as well as the Germans generally are, to the mind of the author,

quite astray with both their malt drying and their mashing processes; and he believes that what Liebig praises as the very acmé of perfection is merely a drift in search of large extracts, which, coming in contact with organic laws, produce of necessity that fermentation which he attributes to scientific skill. A good refreshing light beer is doubtless brought into the market, but it is neither more pleasant, nor does it possess more power of keeping, than good "table beer" of this country's make. In fact, the article is sensitive to a high degree, and the most of it is only kept from running to destruction from the moment it is brewed by being immersed, so to speak, in ice—ice in the fermenting rooms, ice in the cellars, ice everywhere, until it is used.

The author has conversed with German brewers, and seen the German processes on a large scale, and he believes these people would be glad to exchange their system for ours; but the course has been towards the concoction system for years, because the beer would not keep when treated on the English or infusing system. Why the infusing system has gone down, and the decoction and ice system has increased, may be a question in the history of kilns—a question, perhaps, of the substitution of atmospheric drying in place of curing with the sulphurous gases of coke or anthracite, from notions of cleanliness following on a loss of tradition, or perhaps a mere loose drifting about, because of never having had proper charts for guidance. For the details of German brewing, the author refers his readers to the matter of a letter taken down for him by an experienced chemist in Germany from the mouths of

German brewers, the difficulty of language preventing him from penetrating the subject for himself in a satisfactory manner. The letter shows that the two most vicious points in mashing are being practised, viz.:—going down too low and up too high on the thermometric scale; and it shows, too, that the brewers are aware of the extreme delicacy of their operations from these causes.

"CHEM., LABORATORIUM,
"WIESBADEN, *January 29th, 1876.*

"MY DEAR SIR,—I am unable to find a direct and sufficient answer to your questions, therefore I take the liberty of sending you a sort of general sketch of the mashing process in use in Germany. There are two kinds of mashings in use. One called the Process by Infusion, and the other the Process by Decoction.

"I. *Process by Infusion.*—This method is much in use in North Germany. The water necessary for *moistening* and *mashing* is altogether, or by portions, heated in the pan or copper, and used when it reaches the temperature of 40° or 50° R. (122° or 144·5° Fah.) in summer, or 50° to 60° R. (144·5° to 167° Fah.) in winter. The quantity necessary for *moistening* is let into the mash-tun, the ground malt poured on it and well mixed. The *moistened mass* ought to have a temperature of 30° to 40° R. (99·5° to 122° Fah.). When the water in the copper begins to boil, it is allowed to run into the mash-tun and be well mixed with the contents of the same, until the temperature is raised to 50° or 60° R. (144·5° or 167° Fah.), the mashing or sugar-boiling tem-

perature,—then allowed to stay about an hour. There is danger in letting it stay too long, because lactic acid ($C_6 H_{12} O_6$) is easily produced. The conversion of the starch into sugar can be conveniently superintended by pouring a small portion, after cooling it, into solution of iodine, which gives a dark-blue, violet, and yellow-red colour, according to the amount of unconverted starch. The first wort is drawn off, and heated in the copper as quickly as possible to a temperature exceeding 60° or 65° R. (167° or 178·25° Fah.). *Nothing has a greater tendency to spoil than a solution like the first wort, charged with nitrogenous substances, if allowed to remain any lengthened time by a temperature of about 40° R. (122° Fah.).* After the first wort has been drawn off, more boiling water is brought into the mash-tun, and well mixed, &c., until the whole reaches a temperature of 60° R. (167° F.), and then allowed to rest from half-an-hour to an hour. After the second wort is obtained, the remainder of the water is *sprinkled* over the malt, the scum or dough which lays on the top of the coarser grains having been previously removed, which would have prevented the water soaking regularly through the whole mass. This scum is chiefly composed of starch envelopes and disintegrated gluten.

"II. *The Decoction Process.* — The beer in South Germany, Bavaria, Wurtemberg, Baden, and Bohemia is prepared chiefly by this process. There are many modifications of it. Three of these are distinguished in Bavaria, viz.: 1. *The Munich or Old Bavarian Process.*— For 100 lbs. malt about 800 lbs. water are taken. From

one-half to two-thirds of the water is brought cold to the mashing-tun, and the remainder of the water is brought into the pan and heated to boiling. The moistening occurs generally about three or four hours before the boiling of the water. This long staying must not take place except when very *cold water* has been used, because the *tepid mash* gets sour very easily. When the water in the pan boils it is brought to the mash-tun, and the temperature of the whole raised through this mixing to 24° or 30° R. (86° or 99·5° Fah.), according as one-half or two-thirds of the water was used for *moistening*. After this about one-third of the mash (but the thin portion) is brought from the mash-tun into the copper, and here quickly heated to boiling, diligently stirring the whole time with a copper spade, and kept boiling for about half-an-hour. This part of the mash is now again brought back into the mash-tun, where it is well mashed up with the whole for about a quarter-of-an-hour, in order that a complete separation might take place between the light fine and the heavy coarse portions. Directly after the mashing is ended, one-third of the mash, now the thicker portion, is brought into the pan, and boiled for half-an-hour. By again bringing this portion back into the mash-tun, the temperature is raised to 48° or 50° R. (140° or 144·5° Fah.). After well mashing, the liquid portion now of the mash is brought into the copper, and boiled for a quarter-of-an-hour, and then again brought back into the mash-tun. The quantity of the clear mash ought to be so much that the temperature of the whole will be raised by it to 60° R. (167° Fah.). After *long*

continued mashing up, the whole is left quiet for an hour and a-half, when the wort is drawn off, boiled, hopped, &c. When so much of the wort has been drawn off that the malt remaining behind begins to appear dry on the top, the fine portion of the paste remaining on the surface is removed. In brewing summer beer (the strongest kind of Bavarian beer), 30 lbs. of water are taken for washing out the malt when 100 lbs. malt was originally taken, and the wort thus obtained brought to the previous wort. In making winter beer (a weaker kind of Bavarian beer), double this amount of water is used to wash out the exhausted malt. The water for washing ought to have a temperature of 76° R. (189·5° Fah.). After the malt used for summer beer has been thus washed out, it is again treated with 50 or 60 lbs. water for every 100 lbs. malt taken to work, and the weak wort obtained used for making small beer, in Munich called Scheps.

"2. *Augsburg Process.*—In this process, because the mash is less boiled and worked, only 600 or 700 lbs. water are employed for 100 lbs. malt, according as winter or summer beer is intended to be prepared. So much of cold, or during *very* severe weather, slightly warm water is mixed with the malt in the mash-tun as is necessary to moisten it thoroughly, and to work it into a regular mass. Very often some hops are spread on the sieve or false bottom of the mash-tun, then the dry ground malt spread over them, and water poured over to moisten, without working it up. The hops are employed partly to prevent the fine portion of the malt from falling through

the sieve bottom, but chiefly to prevent the sudden souring of the mealy portion, which, nevertheless, does go through the sieve or perforated bottom of the mash-tun. The remainder of the water is heated in the copper to boiling. In about four or five hours after moistening, the liquid in the bottom of the mash-tun, and what will run from the malt, is drawn off. This is called the *cold Satz*. A few litres of this liquid is put to the water in the copper as soon as it begins to boil, and then kept boiling more or less time, according as the water is a hard or soft water, but generally about half-an-hour. The impurities in the water are thrown down and separated by the coagulation of the albumen dissolved in the liquid. After scooping these impurities away, so much of the boiling water is brought to the mash-tun that the temperature of the whole mash reaches 48° R. (140° Fah.) to 50° R. 144·5° Fah.), mixed well and left staying for a quarter of an hour; generally the whole of the water is used for this first mashing. Now the remainder of the *cold Satz* is brought into the copper, and the *first wort* is allowed to run from the mash-tun. About 15 or 20 litres of this unboiled wort (when 100 lbs. malt are treated) are brought into the cooler and cooled as quickly as possible, to preserve it against bad influence. This is called the *warm Satz*, and will be united to the rest of the wort before the boiling with hops. It has the object of giving the beer a greater mildness and shine, which it seems to effect by producing a stronger fermentation. Only about two-thirds of the first wort is allowed to run from the malt, and brought with the *cold Satz* slowly to boiling

in the copper, removing the scum so long as it is produced in any great quantity. The boiled wort is then allowed to run into the mash-tun, mixing well the whole time, and the temperature of the mash will be raised to 50° or 52° R. (144·5° or 149° Fah.). After having mashed it up well, the thicker portion of the mash is brought to the copper, and as quickly as possible heated to boiling, when it is generally kept boiling for about an hour; then, if no more scum is produced, it is considered to have been boiled enough, and a sample taken from it should clear up soon, and show a dark grey lustre. When it has been sufficiently boiled it is brought back to the mash-tun and well-mixed with the rest of the mash; then left for about an hour and a half quiet. During this, the warm Satz (the 15 or 20 litres which was formerly cooled) is brought into the pan, and with this Satz the necessary quantity of hops are put. At the end of an hour and a half the clear wort is allowed to run off from the mash, and brought to the pan, where it is slowly heated with the Satz and hops, and boiled into beer. The complete exhaustion of the malt is made by pouring cold or hot water over the remains. From 100 lbs. malt about 30 lbs. dried remains are obtained, which in a wet state hold about 80 lbs. of water. The above method is very much in use in Wurtemberg, where they often do not bring any of the first liquid into the cooler, fearing the mischief which might happen by keeping an unboiled wort, especially during warm weather: but with great cleanliness, and the employment of good *highly kiln-dried* malt (as is necessary for Bavarian beer), no mischief easily occurs.

"A third Bavarian process, called the French method, is as follows: the ground malt is brought into the mash-tun in the dry state, and when the water in the copper boils, cold water is mixed with it until the temperature is reduced to 66° or 70° R. (180·5° or 189·5° Fah.). Then it is allowed to run to the mash-tun, and is well worked with the malt. The water should not be allowed to run in too quickly, in order that the temperature may rise more gradually. The whole of the water is employed for this first mashing, and the mash should have a temperature of about 50° R. 144·5° Fah.) From 600 to 700 lbs. of water is taken to every 100 lbs. malt; and after staying a short time in the mash-tun the first wort is drawn off and heated in the copper to boiling, and generally kept boiling three-quarters of an hour, when it is brought back into the mash-tun, where the whole will acquire a temperature of about 60° R. (167° Fah.). After well mixing, the whole is allowed to stay quiet for one hour, and then the finished wort is drawn off. The hops are very often in this process boiled for half-an-hour with a small quantity of the *first wort,* which imparts to the beer a peculiar taste. This is called roasting the hops. The remains are washed out with cold water, and the wort so obtained used for making a weak beer."

All the fermentations are conducted at as low a heat as possible, and 55° Fah. is the uppermost limit. About ten days are required to finish a brew, when it is stored away among ice in large casks, carefully pitched inside,

and waits to be racked and sent out in transit casks, varying from a half-firkin to a barrel in size.

The above are some of the practices arising from the different opinions of the Germans on beer making, and it may be surmised that the fermentations will vary with the different heats employed, and periods of exposure of the goods to such heats. Indeed, it is known that the tun heads vary in appearance considerably; some having only a slight scum over, or a small bonnet of floating yeast in the middle when the fermentation is active, going to the bottom of the tun, however, like the other portions, towards the end of the fermentative action. Other heads do not vary much from those on English, or rather Scotch tuns, though all deposit more largely. The author begs it to be understood that his sketch of German brewing, although fully as lucid as anything given in this country hitherto, is very imperfect. Only long practice and observation could enable anyone to speak thoroughly of the merits or demerits of such a complicated system. His opinion, however, is that no gain is got over the English system by so many abtruse practices.

DESCRIPTION OF PLATES.

Plate I.

Plate I. is a drawing of an apparatus proposed for hardening water for brewing purposes.

The desideratum with brewers confined to soft water hitherto has been to get carbonate of lime taken up, on account of its being insoluble except in the presence of carbonic acid gas. Thus the methods of hardening have been confined to preparations of the sulphate, or using the carbonate and sulphate together, both being very finely ground in the water copper or mash-tun. The results by this method, so far as the carbonate is concerned, have been considered a failure, and hence the proposition advanced.

The structure consists of a round tower *AA* of considerable height, with divisions at suitable distances on which to pack clumps of limestone, marble, or chalk; the purer of the three being best if comeatable. The tower is surmounted by a gasometer *BB*, to contain and regulate the supply of gas. Above the tower, on a suitable platform, is placed the acid vessel *C*, partially filled with muriatic acid. From the vessel *C* the acid descends to the Generator *D*, filled half full or so with limestone and water; the lime rests on a false bottom, underneath which is admitted the acid to acidify the contents, and promote the dissolution of the limestone. The gas, the product of the action, passes up the pipe *a* into the first washing vessel *E*, whence, bubbling

upwards through the contained water, it passes by the pipe *b* into the second washing vessel *E*, from which again it passes by the pipe *ccc* into the tower under the gasometer. Here the gas meets the water being supplied from the pipe and rose *ee*, and the water and gas charged with each other passing down through the limestone takes it into solution, and runs, or is pumped, off by the pipe and cock *g*. The cock *h* is meant for cleansing purposes.

Sulphate of lime to mix can be thrown into the water copper in a pulverized condition, and roused into the water, when the mash is being made, by a hand scrubber or a rousing machine, such as is attached to the porter copper. If the tower, however, is found to present surface sufficient to charge the water with both the carbonate and sulphate, the shelving construction of it permits of this, and indeed the shelving is introduced for the purpose.

The arrangement is shown as self-acting, the plug in the acid vessel—which is enlarged for a better illustration—being intended to be worked by the movements of the gasometer. The gasometer itself is not strictly a necessity of the system, but is introduced as an indicator of the gas pressure, and to assist in regulating the same.

It will be seen that the supply of water to the Washers enters by the pipe *f* placed in the first Washer *E*, passing through into the second Washer *E* by a connecting pipe at the bottom. A pipe *d* connects the bottom of the Washers with the Generator, so that in charging this vessel the waste Acid in the Washers may be to some extent utilized.

The author has made partial trials of water impregnated thus with carbonate of lime, and with the sulphate supplied roused into the water copper, and the results were such as to convince him that fine beers can be made anywhere that pure water and limestone can be had, and where a suitable climate exists.

The recent movement of the London brewers to Burton to make their beers was a result of ignorance of their position and requirements. So far as water was concerned, all they had to do to make water equal to Burton was to add 20 or so grains to the gallon of sulphate of lime to the water in the copper. This is known to have been tried by some brewers, but the copper heat question affected the pale ale brewings, and this, with the careless mash heats introduced from the porter departments, neutralized their efforts. Some of the brewers went even the length, under the leading of their engineers, of taking London coppers to Burton.

Analyses of several brewing waters are given to confirm the statement that carbonate of lime in excess is found in porter waters, and the sulphate in excess in fine beer water. The Scotch waters seem, if anything, to be fully as suitable for porter as for beer.

Brewing water containing organic matter ought, as far as possible, to be boiled before use.

Examples of two good domestic waters, the Loch Katrine and the Vartry, are likewise given as samples at the disposal of brewers for synthetical purposes.

Plate II.

Plate II. represents a kiln for drying and curing malt for brewing. There is nothing new about it, but is selected as the best possible form for the purpose to which it is supposed to be applied. It was in common use fifty years ago, and is the oldest form of malt or corn kiln known to the author, and was the only kiln, to his recollection, in use at that time.

Explanation of this plate is hardly required by practical men. The furnace is marked *A*. The lamp, the purport of which is to help to burn smoke, and, so far as it may, contain and graduate the heat, is marked *B*. *CC* is a sloping pyramidal shape of wrought-iron to keep the kiln dust off the lamp and furnace, and it is covered with brick for heat retention and distribution. Kilns cannot have too much of this reservoir principle in their construction.

DD is the floor for the malt, and is shown in perforated brickwork, now admitted on all sides to be the proper material for a kiln floor, while *E* is the ventilator.

A peculiarity of this design is that the floor and roof are taken down to the dimensions of former times, instead of being shown lofty and palatial as the modern structures have been raised. The floor need not be over half a diameter in height, and the roof ought to be as low as just to permit men to work under it, with the ventilator placed as low as possible. The furnace and ash-place are shown with doors on each, so as to give full regulating

power; and the air vents on either side have movable slides for the same purpose.

The mode of use is to keep open the doors and slides until the malt has been turned twice, and the steam just gone. After this the slides are half closed, to let the curing begin, and gradually drawn closer as the malt dries, until at last they are shut altogether; the finishing being completed with the furnace alone, as atmospheric air admitted at the final stage neutralizes all that has been done before in the way of curing. The furnace door is meant to be shut to urge the heat, and the ash-place door to check it when required. These are both very useful in the case of making amber malt. Modifications of this form of kiln are to be seen in the Burton district and elsewhere, but in some places the arches have been altogether dispensed with, and the drying carried on in an open space, entirely without the delicate regulating power necessary to conduct the curing operation to a successful termination. One way of using the open kiln has been pointed out in the article on kiln drying, viz., by thick loading; the other way is to close it all up when in use, so as almost to stop the draught, and work with a fire no larger than to consume what oxygen passes through the seams and keyhole of the door. It takes a week to dry malt on this method, but it is thus at least thoroughly cured.

Kilns ought to be circular, but the internal arching and fittings are so difficult that they are seldom so made. They should never be larger than a man's power to throw

the malt from the walls to the centre, and, in turning, eighteen inches of the malt round the walls should always be thus thrown in, and the turning performed outwards from the centre for the purpose of averaging the drying.

The oblong kiln with several furnaces is not a safe one, and all the worse when open and unarched below. Worse still when mounted on the top with two or three ventilators, or one the whole length of the roof, as then the wind may go in by the one end and out by the other, making sport with the draught, and moving it about so that drying and curing become impossible.

If proof is needed to aid conviction of the necessity for brewers taking up the kiln question in construction and working, that proof stands forth in the fact that the old mild beers and ales, made with 4 or 6 lbs. of hop to the quarter of malt, had as much keeping quality as the beer now made with 10 to 20 lbs. of hop—not to speak of malt wine, which was made entirely without hop. As to the mild ale made now-a-days, it will hardly keep as long as get into drinking order, hop or no hop, strong or weak; and the style which it had in former days—as regards the Scotch ales—is completely gone. The kiln question likewise explains why cane sugar and the other compounds used in brewing are without keep—they want curing.

Plate III.

Plate III. is a diagram showing the heat movements and turnings of a kiln of pale malt. The time given is three days, but this short period is laid down out of deference to

the present almost universal practice to dry off in from two to three days, and the necessities of existing plant. The author believes that malt cannot be properly cured under four days, and that a day more rather than one less is required. When three days only can be allowed it is all the better that the process be clearly understood, and the diagram is introduced to familiarize parties with the requirements of the case, and to show the necessity of such a careful and constant attention as will give the best results from this abnormally short allowance of time. On the horizontal line is marked the hours as they pass from stage to stage of turning, while the vertical line exhibits what ought to be the rise in heat during those periods. *A* represents the loading stage, with the heat of the malt about 60°, the loading being supposed to have been performed in the forenoon, from ten to twelve. *B* indicates a turn at 3 P.M., to help to discharge the excess of moisture in the malt; and *C* the evening turn of the same day, for the same purpose, but with the additional intention of fitting the charge to lie in safety until the morning. The heat is shown as having risen during the day from 60° up to 100°. *D* is the morning turn of the second day, showing a further rise in heat of 20°. The drying and increasing of heat goes on in the same manner through *E*, *F*, *G*, and *H*, at all of which three points the malt is supposed to be turned. *H*, however, stands on the morning of the third day, when the malt has reached a heat of 160°, and on which day it must be finished and taken off. *H* likewise represents the morning turn at about 7 A.M., after which turn the heat may

be allowed to rise—in sight—a matter of 10°, and the malt get the two turns more represented by *I* and *J*, when under this advanced heat. These two last turns may take place at say 10 A.M. and 12 noon respectively, and within an hour more the malt should be gathered into a heap, to lie for a time under the conditions already indicated, or conveyed to the bin.

What becomes evident from the employment of the diagram is, that considerable care is needed to keep the heat moving steadily upwards, and not oscillating up and down in the intervals of turning. Malt is seldom cared for sufficiently at night; and it is evident here, that to have malt brought properly forward within a very limited period, as in this case, night attention is as necessary as attention by day. When a longer time is granted, malt will do with less supervision, as it may be dealt with at lower and safer temperatures until the day of finishing.

Plate IV.

Plate IV. is a diagram similar to the last, but arranged for amber malts. *A* is the loading stage, *B* the mid-day turn, and *C* that of the evening. *D* puts us into the next morning, at say 7 o'clock, by which time the malt is supposed to have parted with most of its moisture. From this time the heat may rise to say 140° at *E* by 10 A.M., when the workmen being in attendance, the raising of temperature and turning may go on simultaneously, until the height of colour wanted be arrived at. The heat of the kiln rises quickly on shutting the furnace doors and the under venti-

lators, and almost any heat can be got in a short space of time. The opening of the furnace doors and ventilators and the closing of the ash-place door—when one is in use—reverses the state of things, and allows of cooling down sufficient for turning almost at once. The necessity for turning—at intervals of less than an hour—is observable by the crackling of the grain.

In the mention already made of amber malt, it was stated that split clumps of beach or oak were generally used to superheat and finish. Care must be exercised in allowing this malt to part with its excessive heat before storing it away in any close place.

Plate V.

Plate V. is a method of pale and black malt mashing combined. It is not necessary to repeat here what has been said on the general principles of brewing. The illustration is advanced to show the black malt infuser more then anything else; but as regards the plate the matter stands thus: *A* is the ground malt hopper, *B* the outside masher (or saturator), *CC* the mash-tun with internal rakes, *DD* the pipe leading to the copper where beer is being made, *FF* the black malt infuser and rakes, *EE* the pipe for passing the wort from the mash-tun through the infuser, and *G* the pipe from the infuser to the copper where porter is being made.

After the large mash-tun is charged with its pale and brown malts, the proportion of black necessary for the brew is mixed up with water in the small mash-tun or

infuser, at a temperature similar to that of the goods in the other. The infusing of the black malt depends on the time given to the other malts, but when these are infused sufficiently, and ready to be run off, the communication from the small tun is opened to the copper, and that from the large mash-tun is opened to the small one; the semi-pale extract from the large tun being used to dissolve, absorb, and carry off the colouring matter from the black malt in the other. In practice the result has been found to be safe and most economical. All the colour that can be got by mixing the pale, brown, and black malts together, plus the quantity lost in dyeing the grains, is got by this process, while the pale and brown grains—the latter, become whiter by mashing—are now worth one shilling and sixpence the quarter more; in fact, with the saving of black malt, relieved of dying the pale grains, taken at only sixpence per quarter, added to the increased value of the grains, the system to a brewer doing 100,000 quarters is equal to £10,000 a year. Why the brewers will not pick up an item like this is a proof, either that they do not yet feel the necessity of economy, or that they are greatly remiss in attention to their interests. The only doubt in regard to its safety is in the question of the wort losing heat, and this can be corrected by enclosing the pale and brown wort pipe in a steam case, when a few degrees added to the wort in passing will enable it to bear the time lost in the infuser.

Plate VI.

Plate VI. contains mash heat and time diagrams after the principle carried out for kilns. The first diagram on the sheet gives the heat and time lines of the one mash and sparge—or Scotch system. The application of heats being already explained in its proper place, it is repeated here only as far as necessary to trace the lines.

Thus *AB* represents the time and condition of saturation. *BC* is the time spent in raising the heat from that of saturation, 150°, to the mash heat, 156°. *CD* is the infusing period, *D* being the point of setting the tap and beginning to sparge. *C*, *D*, and *E* represent the time of highest temperature, *E* being the point of declination, and *EF* the time of declination. The heats given apply only to the goods.

The second diagram is for a method of two distinct mashes and partial sparging. As in the other, *AB* is the saturating period; *BC* the time of rising to the mash heat proper; *CD* is the infusing time; *D* being the point of tap-setting and sparging; *DE* the time taken by the mash to run dry; the declination here representing time only, the heat of *CD* being continued and carried by the aid of the sparging water half-way down the declination *DE*. *EF* is the time of second infusing, the heat of which is brought to 156° at *F*, and continued so through *FG*, to make up for the necessary loss of heat on *DEF*. *GH* is the running-off time of the second mash, and for sparging up quantity; the sparging heat being reduced to a temperature that

will lower the goods to finish at 150°. Of course, in all these finishing heats of goods the taps will indicate 2° or 3° less.

The third diagram is meant to show a porter mash in progress. *AB* is again the saturating period, which, on account of the high dried, and absorbent malts used, is set at 148°, two degrees less than the beer mash. *BC* is the line of heat rise, *CD* representing a ten minutes' rest at 152°, to give the brown malt time to absorb water, and give out its latent or chemical heat. *DE* finishes the mash and leaves it at 156°. *EF* is the period of infusing, *F* of setting tap and partial sparging, and *FG* the time of running off. *GH* is the re-mashing time—heat rising again to 156°, *HI* second infusing time, and *IJ* running-off time, and finishing with lowered sparge water, as in second diagram.

This mash is shown lengthened out by an hour more than the pale beer mashes, as the brown malt takes longer to extract, and by its superior keeping powers it may be worked on for an hour or two more with impunity.

These latter diagrams let out the fact, that danger may get in by the cooling down of the goods in the interval of draining and mashing.

Plate VII.

Plate VII. is put in to exhibit the lines of bad mashing processes. The two first diagrams represent a state of things which many brew-house books will show to have been common during the period of the introduction of pale ale.

The two shown are *bona-fide*, and taken from mashing records. The first shows not only very bad mash heats, but gross wastefulness of material. The practical brewer was here very ignorant, and, as is usual in the case, very proud; too much so to ask information, and for years threw his employer's profits away to such an extent as to amaze the Income Tax collectors. *AB* here is the mashing and infusing heat, all right; but the sparger goes on at *B*, with the water nearly boiling, and the heat runs up the line *CC*, increasing to dangerous proportions towards the end of the mash. The second diagram is alike erroneous, but it shows that the brewer did give the time necessary for extraction. The lines here, though equally bad for the beer product, are more natural, and are a result of inattention to the effect on the goods of a fixed sparging heat, set at perhaps 180° to 185°. The first diagram must be the result of a sparge heat of 195° to 200°! Neither of the diagrams are at all exaggerated, for even worse examples were within the author's reach.

The third diagram of these abnormalisms represents a porter mash after the manner of the large houses. It only shows three mashes, however, while some concerns take four or five mashes, spending 10 or 12 hours over them. The evil in this is magnified as compared with the pale beer mashes, by the long infusing at so low a first heat; but there is a saving clause in the high dried malts which the pale beer brewer does not possess, and which brings the porter maker through where the other would be ruined. *AB* is the mashing and infusing period, all on one heat level; a heat quite

right to break the goods in at, but quite wrong to allow them to infuse at for so long a time. *B* to *C* is the first draining time, *C* to *D* re-mashing, *D* to *E* re-infusing, *E* to *F* second draining, *F* to *G* third mashing, *G* to *H* third infusing, and *H* onwards to further mashings, spargings, or letchings, at higher and higher heats. As explained in the body of the book, the system gives acidity both from the low heats at the beginning, and from the high heats at the after part of the operation.

The author hopes that the diagrams, although in themselves commonplace affairs, will be useful in bringing home to the natural eye of employers processes which can only be seen dimly at present by the eye of the mind. He thinks they ought at least to assist the other matter in preventing those drifts and fluctuations in quality, which generally follow changes of management in breweries.

Plate VIII.

Plate VIII. is the common form of copper made and used in Edinburgh and Alloa from time beyond memory. It is doubtless an outcome of the necessities for making strong ales, and happens to be the best form for pale beers as well. *aa* is the charging line, about 4 feet 6 inches from the bottom, and 4 to 5 feet may be set down as the charging depth in use, and the most suitable for pale beers; the lesser depth for the stronger, and the greater depth for the weaker beers. A wide shallow copper such as this gives such freedom to the currents going upwards and downwards that no colour from the copper can ensue; the only colour

possible being that from pure density of wort if extracted off the mash-tun, or boiled up to a very high gravity. A natural protection follows the ordinary working of a brew-house in respect to copper colour, from the mash-tuns and coppers generally bearing some relation of proportion to each other. The mash-tun extract of strong beers becomes less as the gravity increases; and the copper charge consequently likewise the less in depth. Shallow boils are of advantage in another way for heavy beers. In making these, boiling in (evaporating) rapidly is of great consequence to procure increase of strength, and a shallow boil may be forced safely to give a higher degree of evaporation than a deeper boil. Besides, a copper does not boil down in proportion to a percentage of its charge, but according to a power determined by its heating surface, force of chimney draught, and other incidents. Thus, a copper with an evaporating power of, say 10 barrels an hour, will, out of a charge of 40 barrels, boil in 25 per cent., while if charged with, say 60 barrels, it will only boil in 16·4 per cent. Taking the charge gravity at ·90 Allan, in the first case the wort would have been boiled up to ·120, and in the other to only ·108, while the brisker boil possible with the shallow charge would make the difference even greater; this brings out the fact that, with a small or narrow copper, a large mash-tun charge for these strong (7 to 12 guinea) ales is a mistake; the smaller quantity bringing about the attainment of the object much better.

Plate IX.

Plate IX. is a model of a porter copper, proportioned so that, with a small modicum of safety valve pressure, it will give heat to bring into a state of perfect caramel the product of brown and roasted malts employed in the manufacture of porter. Without an exposure to heat, evidently considerably over the atmospheric boiling point, these embrowned ingredients are but imperfect caramels. Their extracts give but the ordinary white froth (or fancy, as the old brewers put it) on the tops of drinking vessels, while they are burned-tasted and bitter in so high a degree as to be undrinkable, unless exposed to a high temperature in the boiling copper. Porter wort does not break; *i.e.*, the albumen of the grain, roasted on the kiln into a gum, does not separate from porter wort until it reaches (the author believes) a heat in the body of the copper of 225° to 230°, but he does not think the breaking of the wort has to do with the change of flavour alluded to. He thinks—looking at the brown heads that ensue—that it is rather the result of a conversion of, than a separation of, constituents, and that the browned starch, unconvertible in the mash-tun, is here brought into real saccharine conditions.

The copper is drawn high and narrow, so as to be obstructive to circulation, and so as naturally to increase heat. It is mounted with a safety valve and lever; a vacuum valve (like a still), which ought to be several inches in diameter, and there ought to be on the wall adjoining a gauge to regulate pressure. There is shown a

manhole door, which is screwed down steam-tight after the copper is charged and the hop put in, below which is a sample cork; while the copper is fitted with a rouser to be kept in motion, or at all events get an occasional turn, during the boil. The risk of burning a bottom in these coppers, however, is when the boil is off, and the hop falls down to lie motionless on it, and it is at this time that the rouser should be specially kept going. The author believes that, with a copper boil 12 feet in depth, the copper being made somewhat straight in the sides, the complications of dome, manhole door, and pressing machinery may be dispensed with. A useful peculiarity of the pressure copper is, however, that it may be placed a flat or two under the hop-back, fired from the ground, and force its contents up by its own pressure: this has already been done in two instances and works admirably. The pipe over the safety valve leads the steam up to the brew-house roof or into a vessel for utilization.

Plate X.

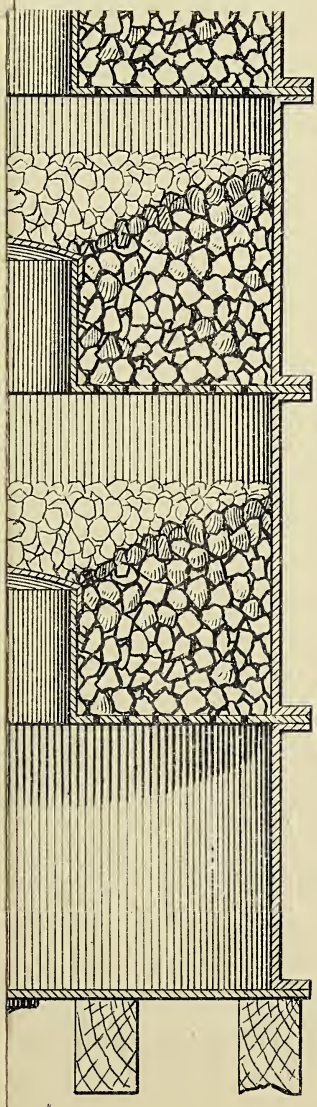
Plate X. is a proposal to facilitate the reboiling of hop with safety in the large pale ale breweries. The subject has already been commented upon, and a simple explanation of the vessels is all that is now required.

The two coppers *A A* are supposed, with a double boil, to take up the extract of a 50-quarter mash-tun. On setting of the taps the coppers are to be filled simultaneously, hopped, and brought to boil; extraction of the mash, however, to continue, and the running wort to be pumped up into the

vessel *B*, which may be styled an over-back. The over-back is supposed to equal both of the coppers in size, and to be charged while the coppers are performing the first boil. Meantime the wort is to be heated as high as possible by a steam coil placed inside it, and, when the coppers are cast, its contents shot into them by the cocks shown for the purpose.

The peculiarity depended upon for protection of the hop and the flavour and soundness of the beer, is by introducing into the brewing coppers the method of surface draining employed by distillers in their mash-tuns, and shown as *a a a a* in the coppers *A A*. When the first wort is boiled and the fire drawn, the hop naturally falls to bottom, and when this is the case, the sluices *a a a a* are lifted out one by one by a hooked iron, fixing into holes shown for the purpose. The plates are well perforated, so that draining to some extent goes on through them, while the surface draining proceeds. Some beer will be left among the hops as a necessity of the system, but this is an advantage, as it is necessary for some moisture to exist in the body of the hop to prevent singeing, until the wort of the second pumping is run in amongst them. For the second boil the drain plates are not restored to their grooves, as the hop is supposed to go to the hop-back in the usual way along with this portion of the wort, after it has been boiled, and from the hop-back it may go to the press in the manner usual in present practice.

PLATE I.



WATER HARDENING TOWER.

PLATE I

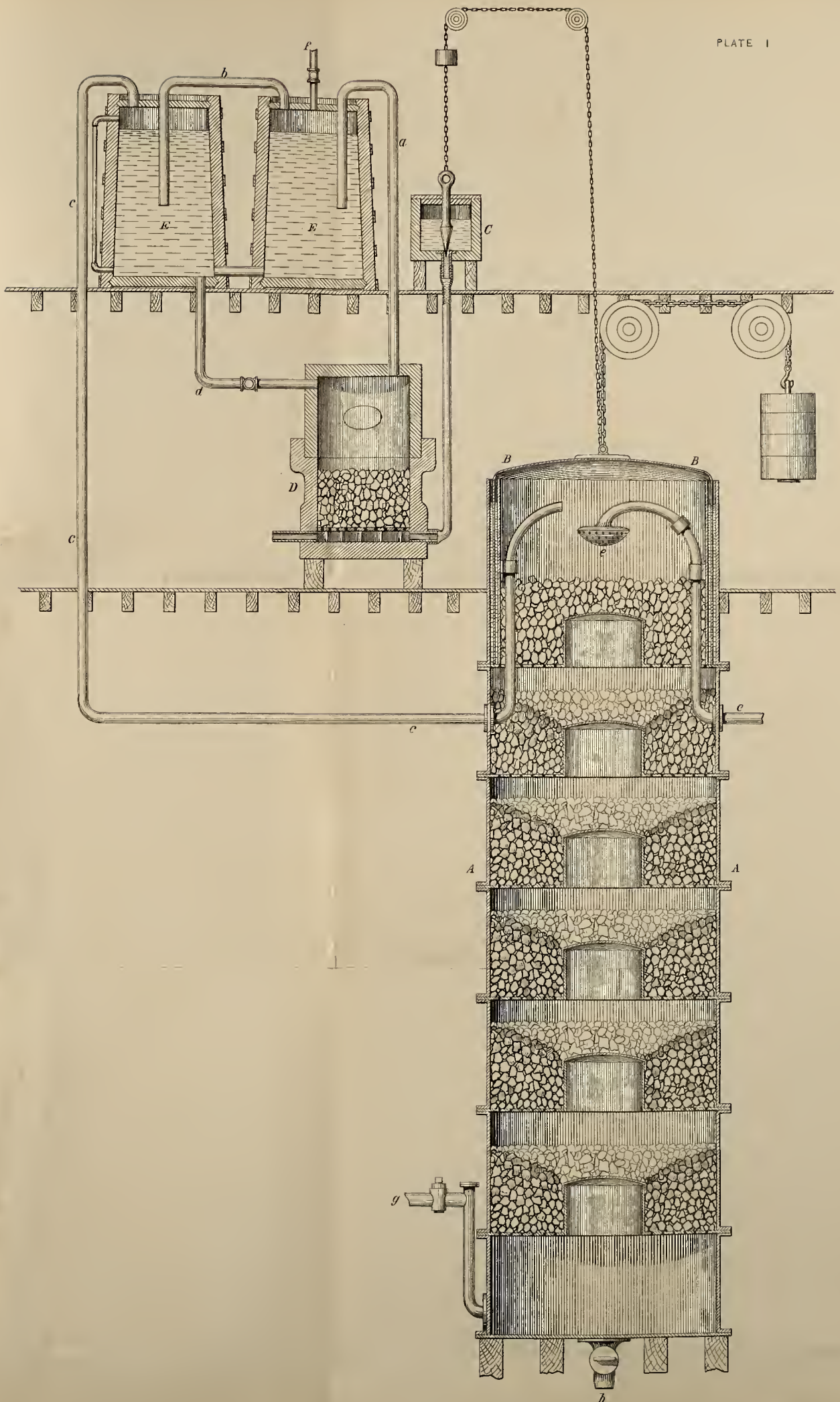
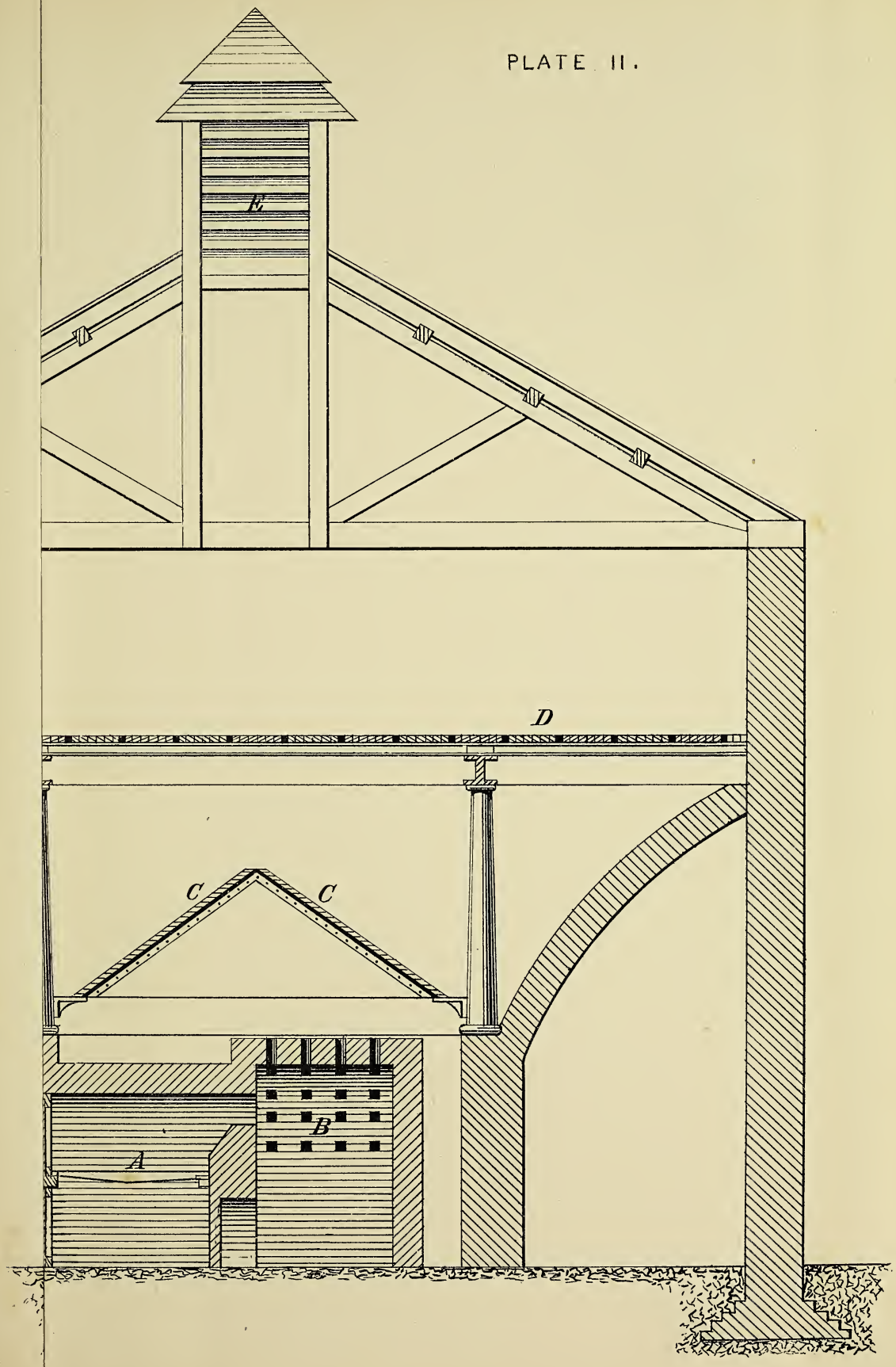
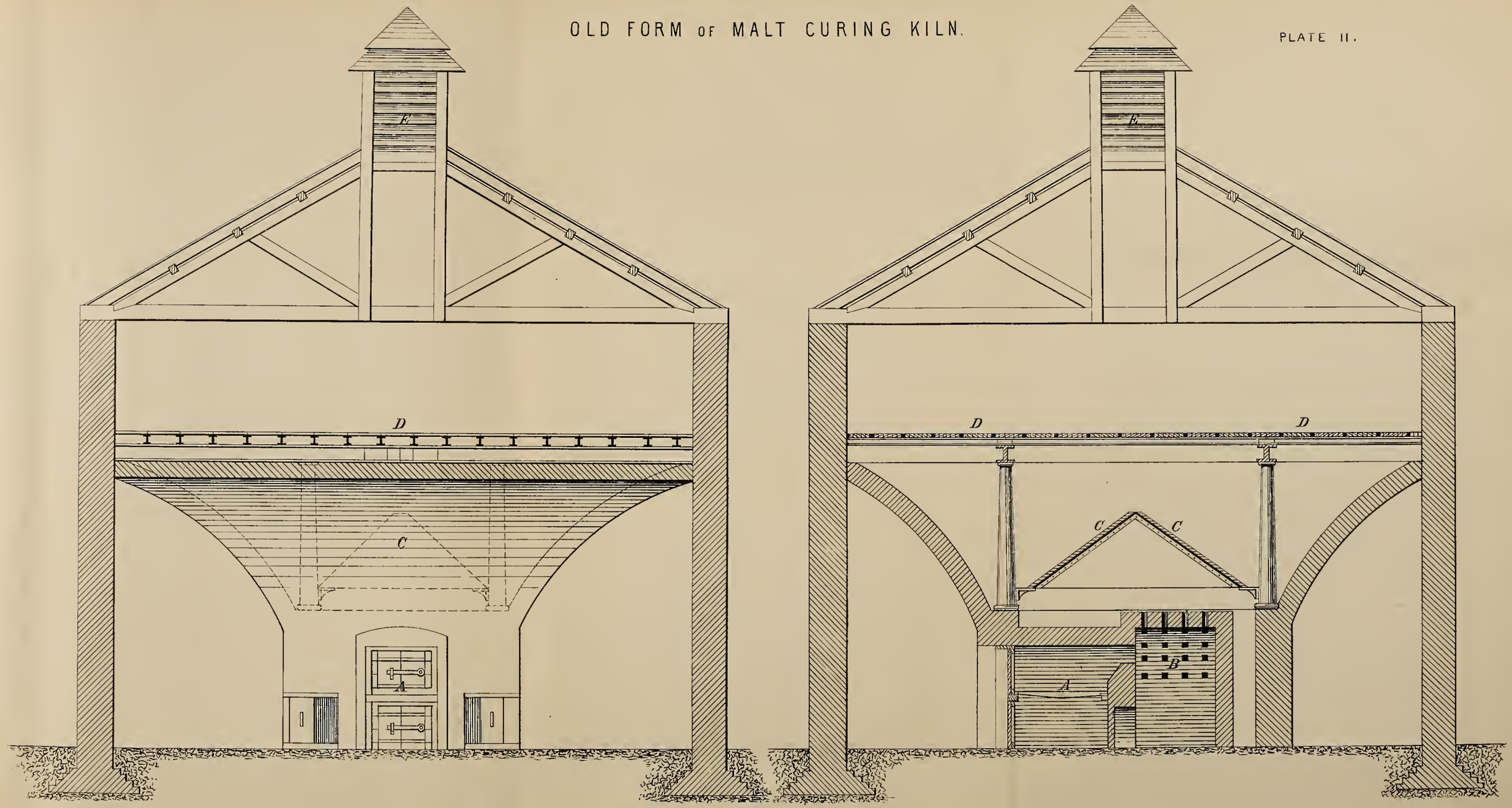


PLATE II.



OLD FORM OF MALT CURING KILN.

PLATE II.



PALE MALT.

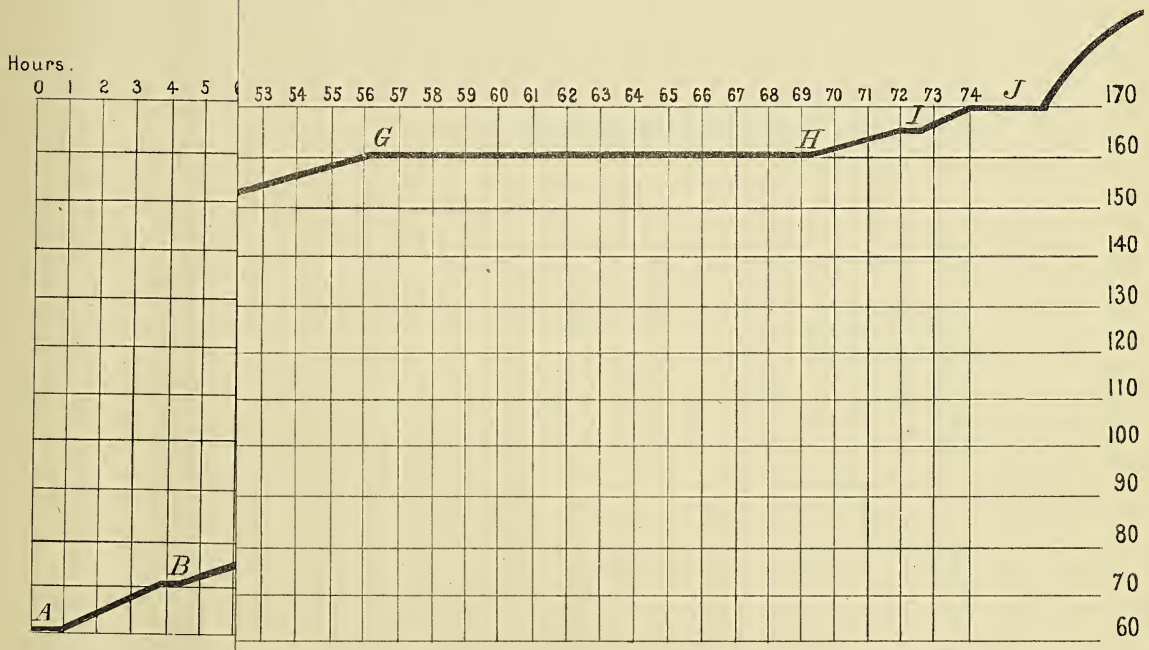
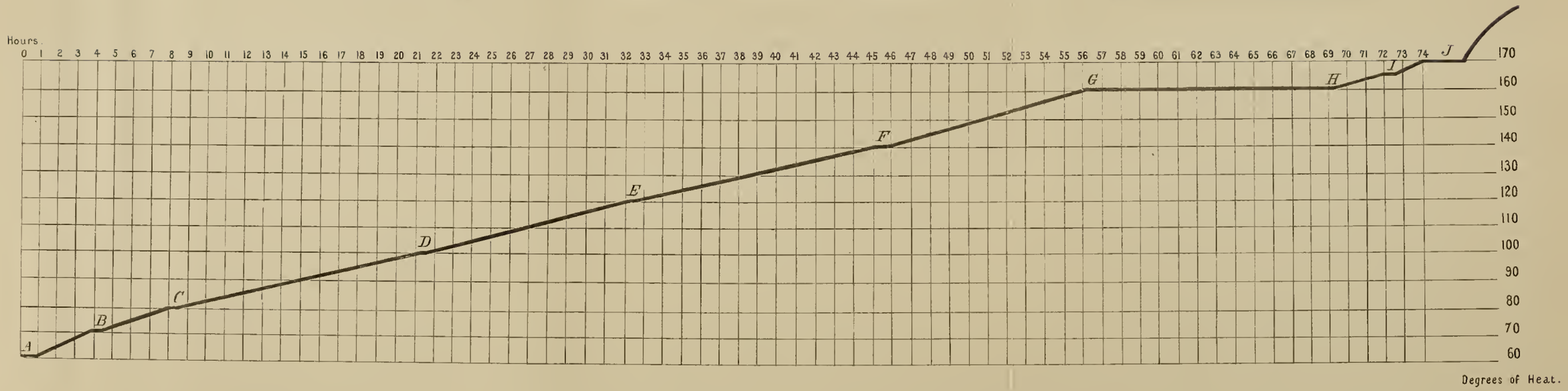
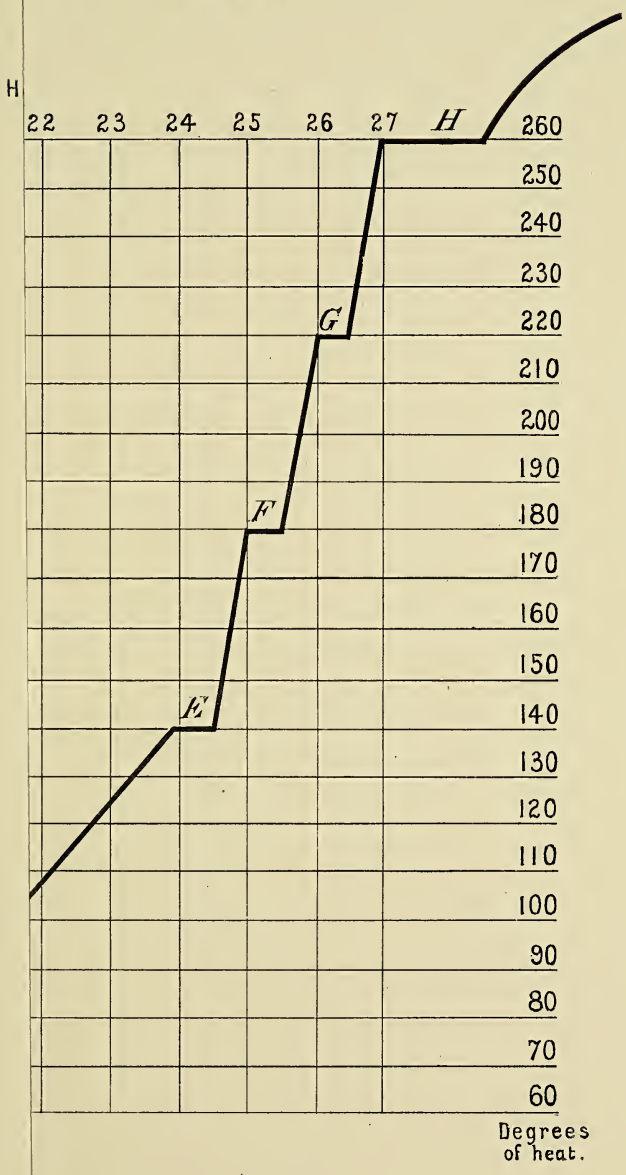

Hours.
0 1 2 3 4 5
53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74
A
B
G
H
I
J
170
160
150
140
130
120
110
100
90
80
70
60
Degrees of Heat.

DIAGRAM OF A 74 HOURS KILN PERIOD FOR PALE MALT.



BER MALT.


H
22
23
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H
260
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230
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200
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170
160
150
140
130
120
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100
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80
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60
G
F
E
Degrees
of heat.

DIAGRAM OF A 27 HOURS KILN PERIOD FOR AMBER MALT.

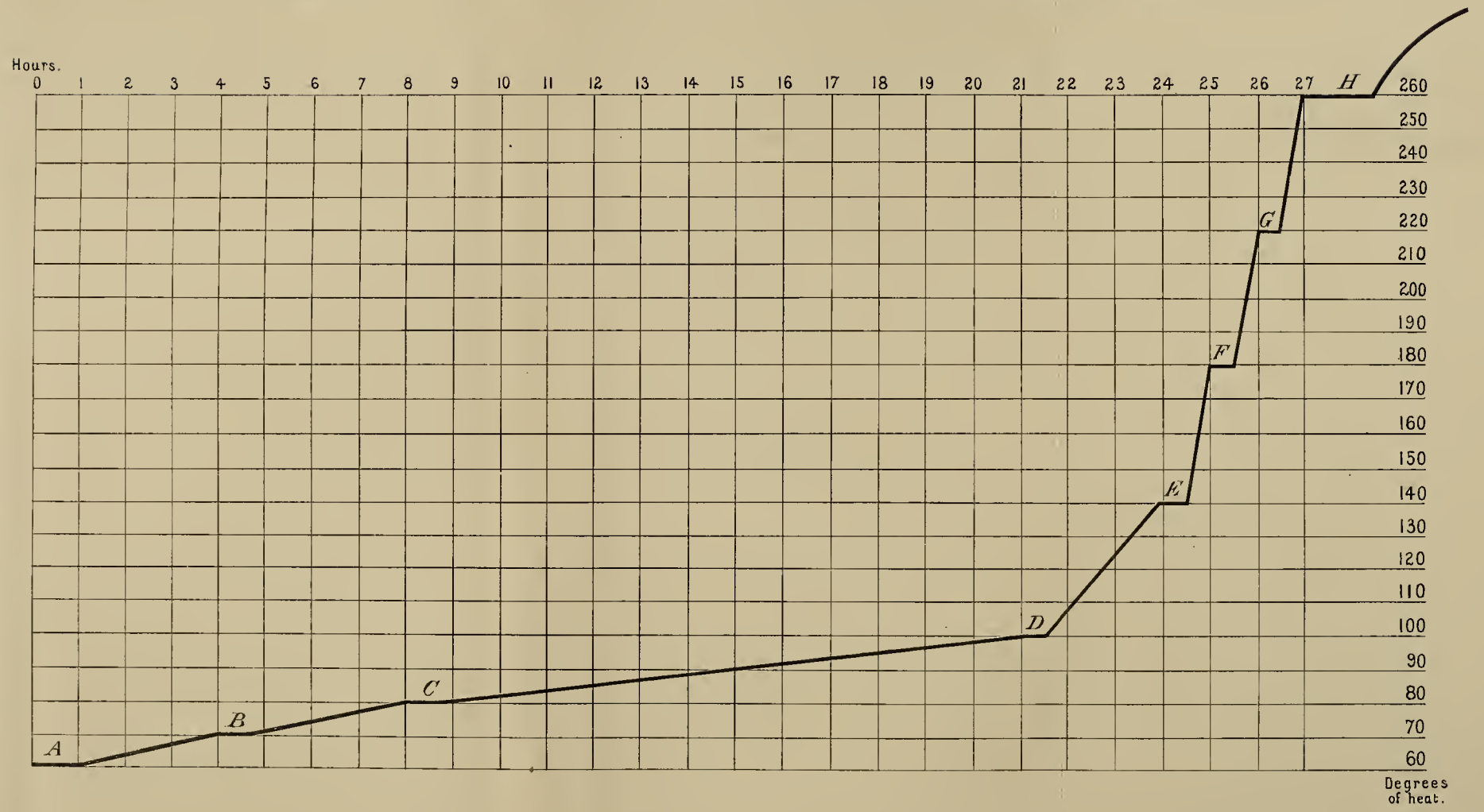


PLATE V.

COMBINED.

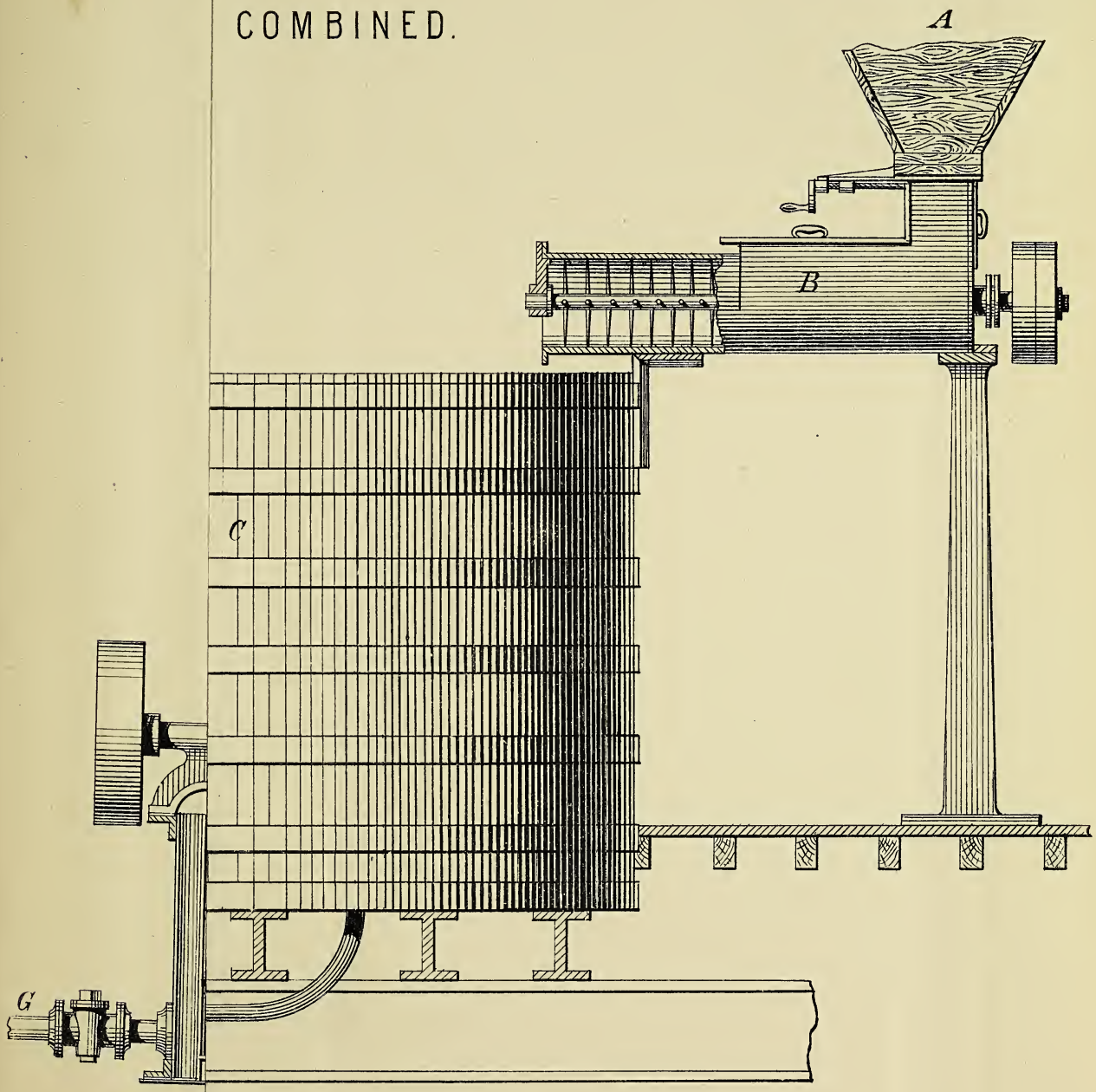


PLATE V.

PALE & BLACK BEER MASHING SYSTEMS COMBINED.

FOR 30 QUARTERS.

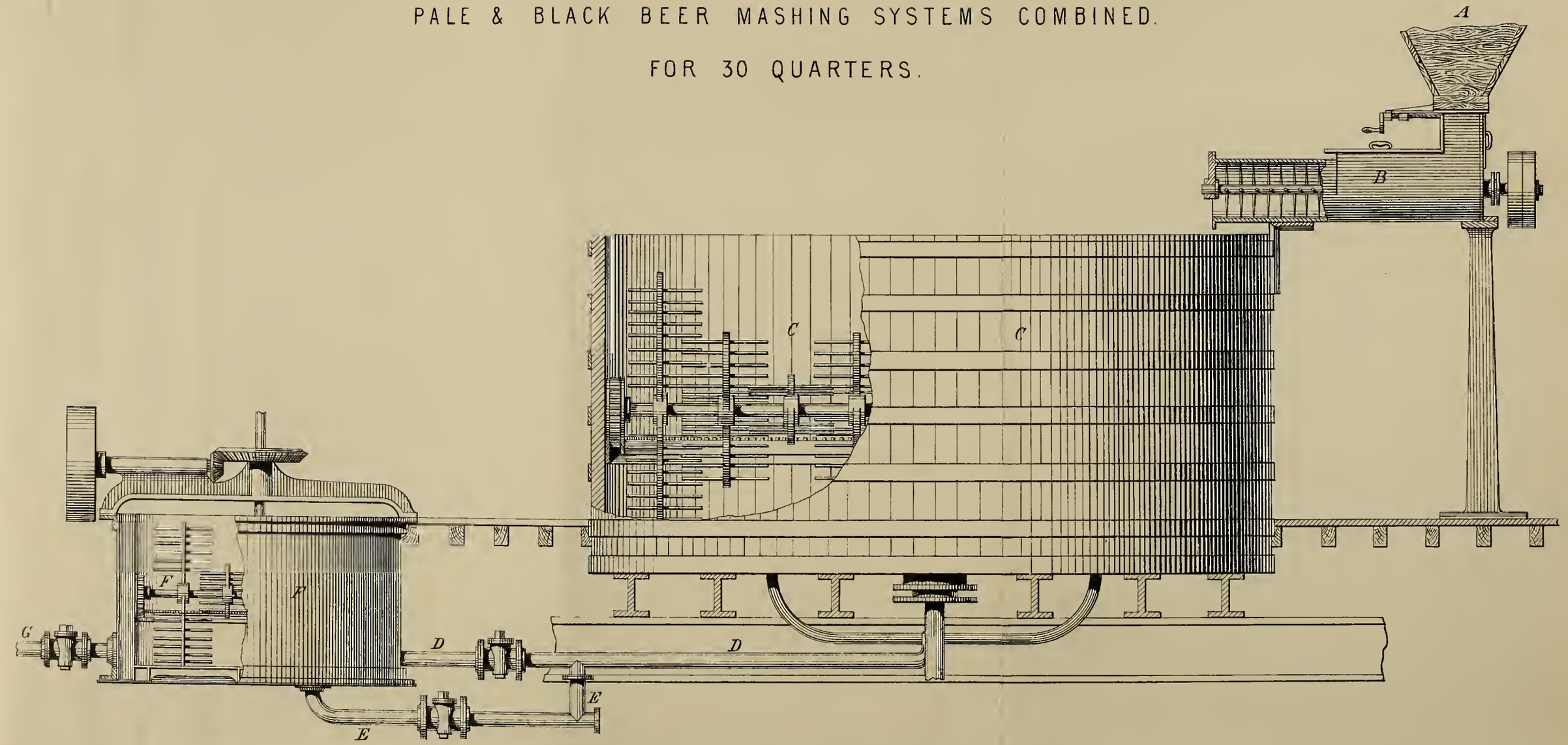
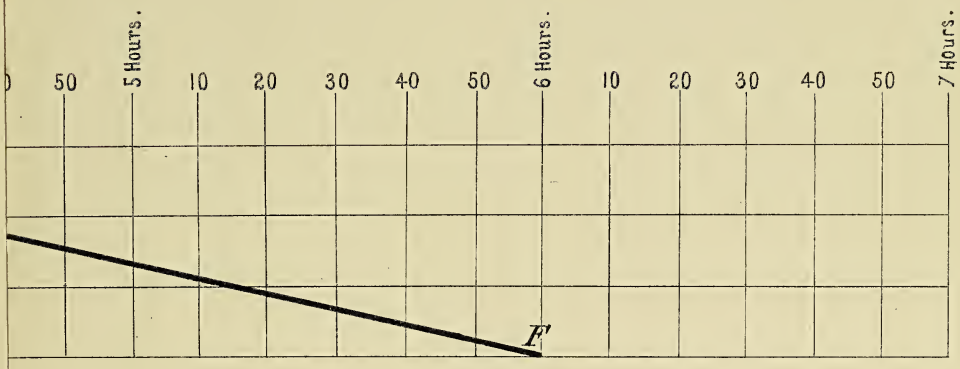
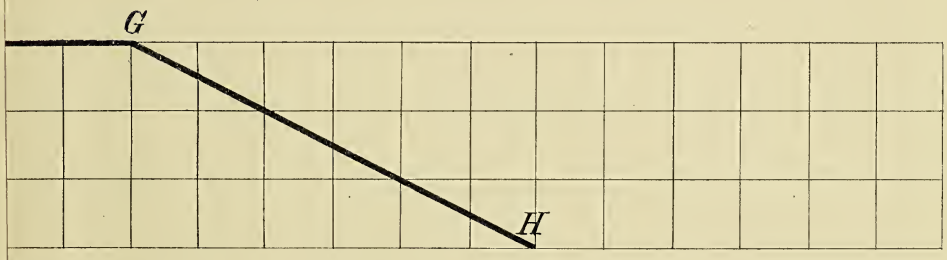


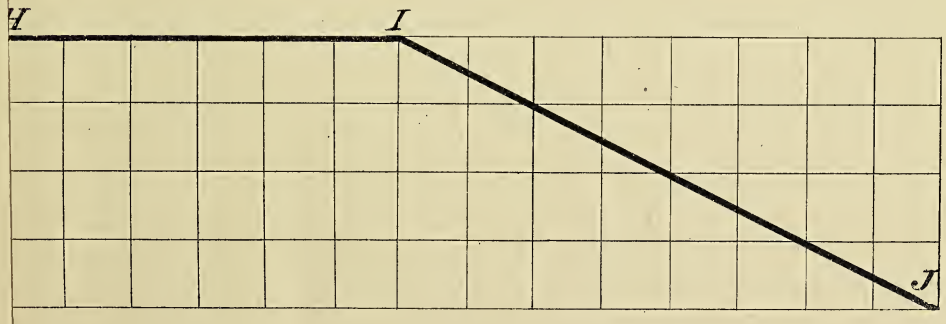
PLATE VI.



RGE.)



ARGE.)



ARGE.)

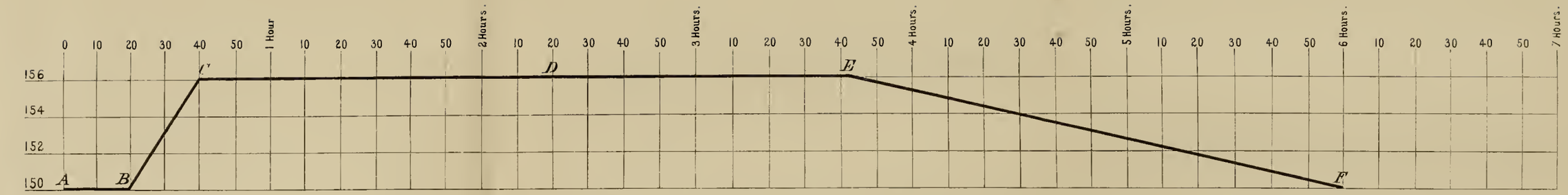


DIAGRAM OF BEER MASH. (ONE MASH & SPARGE.)

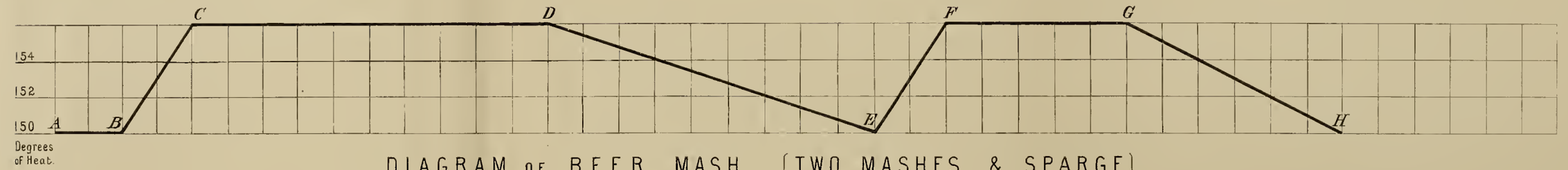


DIAGRAM OF BEER MASH. (TWO MASHES & SPARGE.)

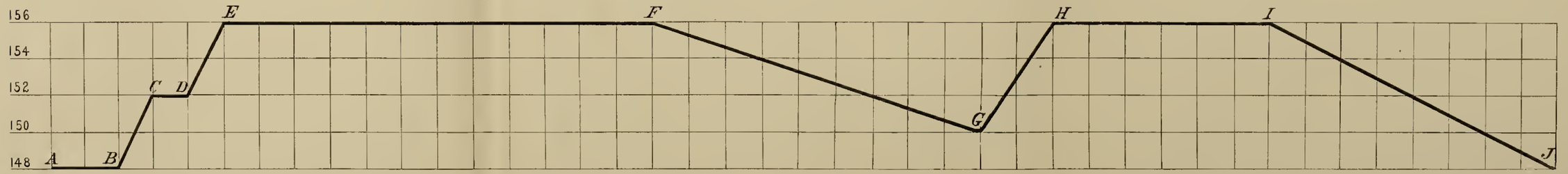
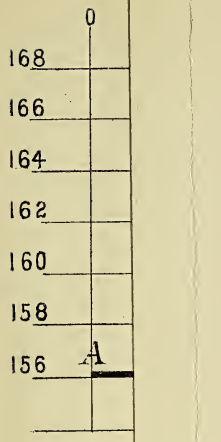


DIAGRAM OF PORTER MASH. (TWO MASHES & SPARGE.)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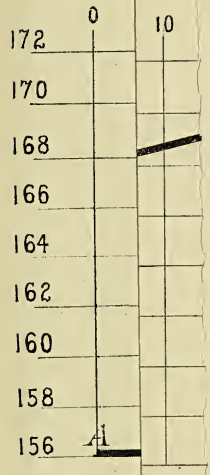
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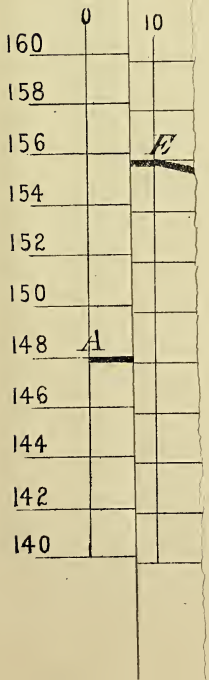
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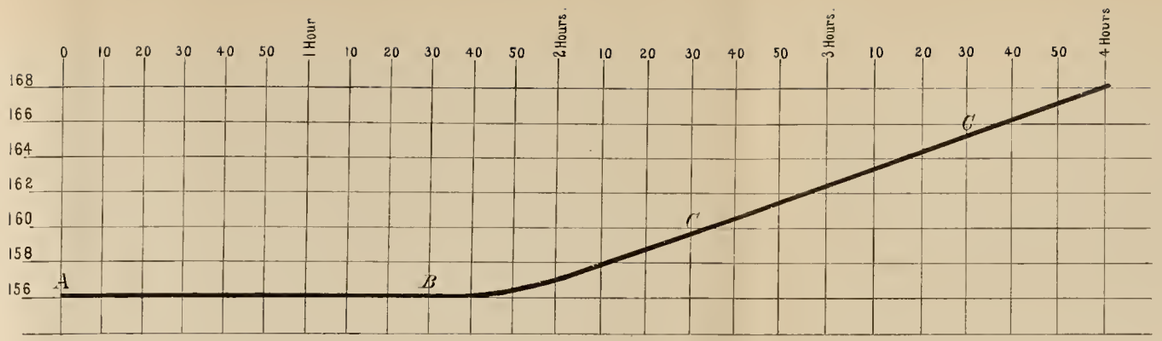
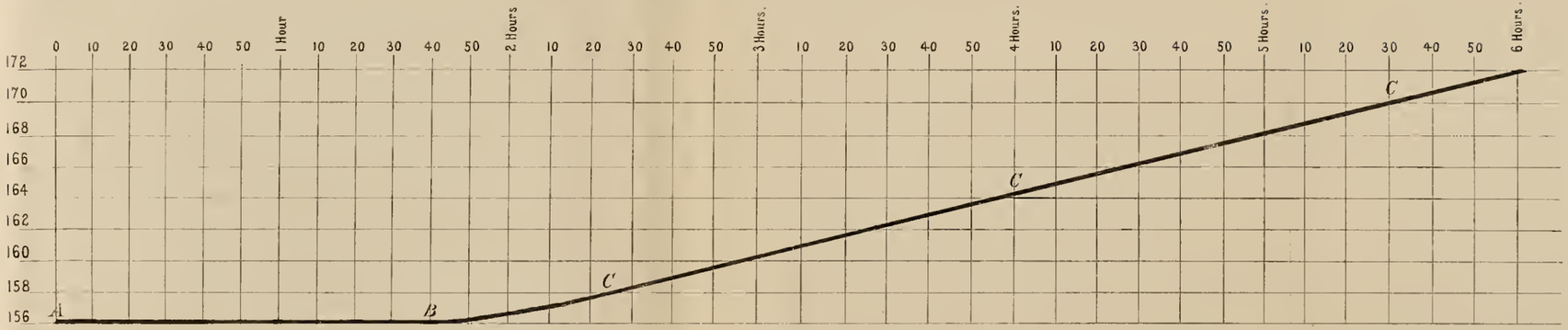
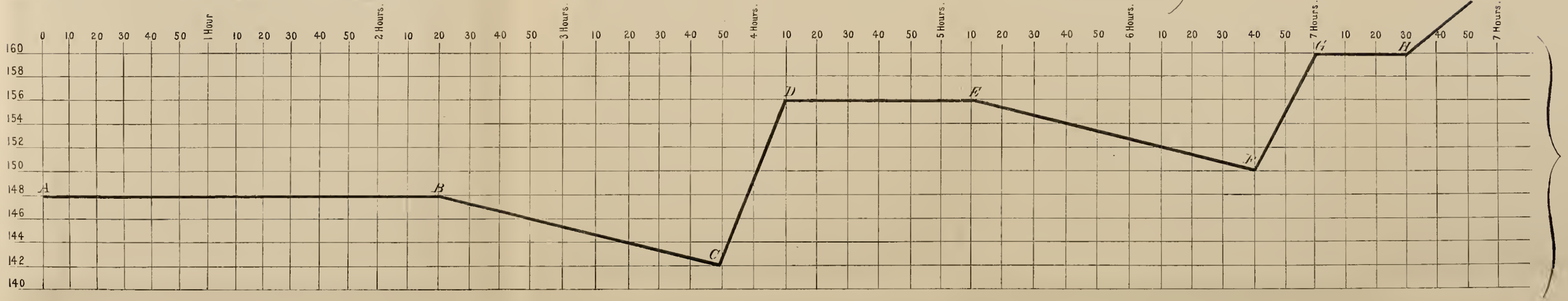




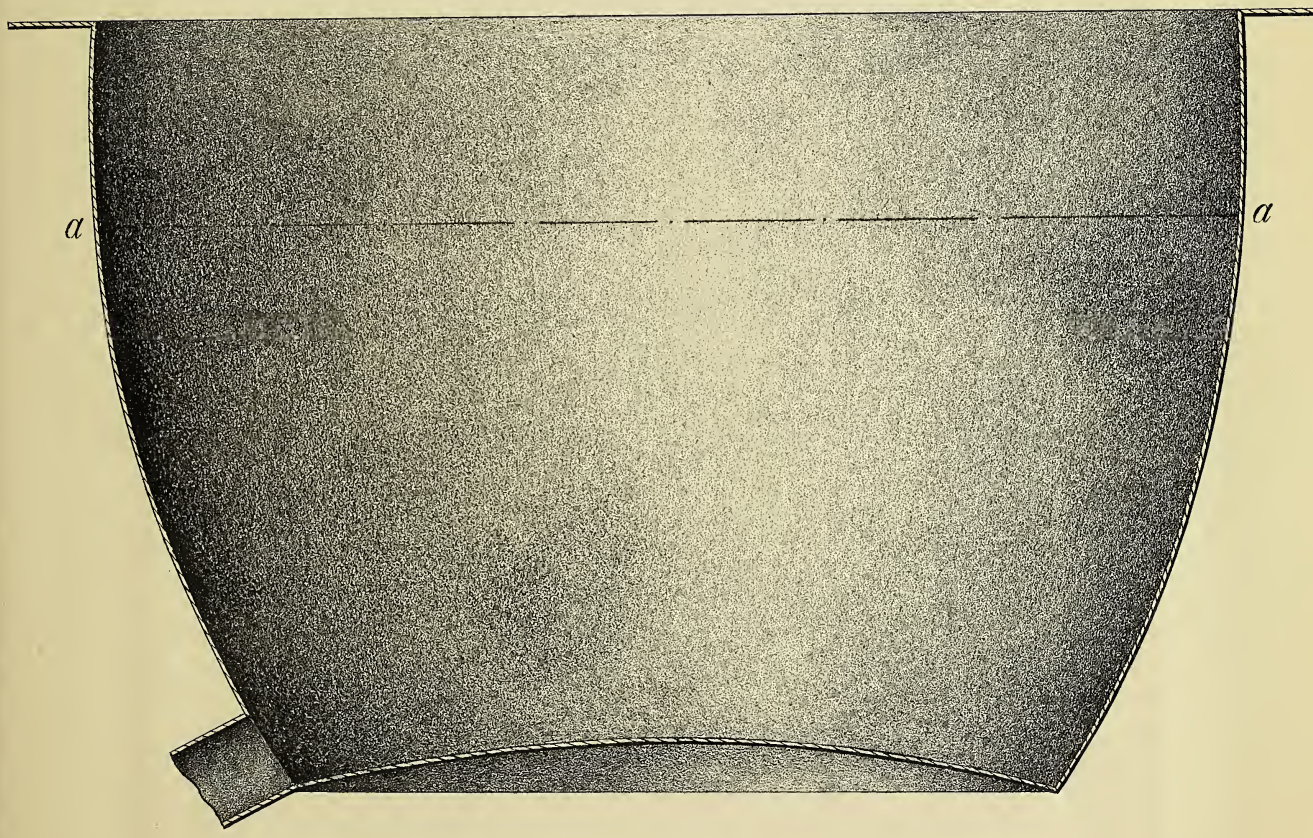
TYPES OF ABNORMAL PALE ALE MASHES.



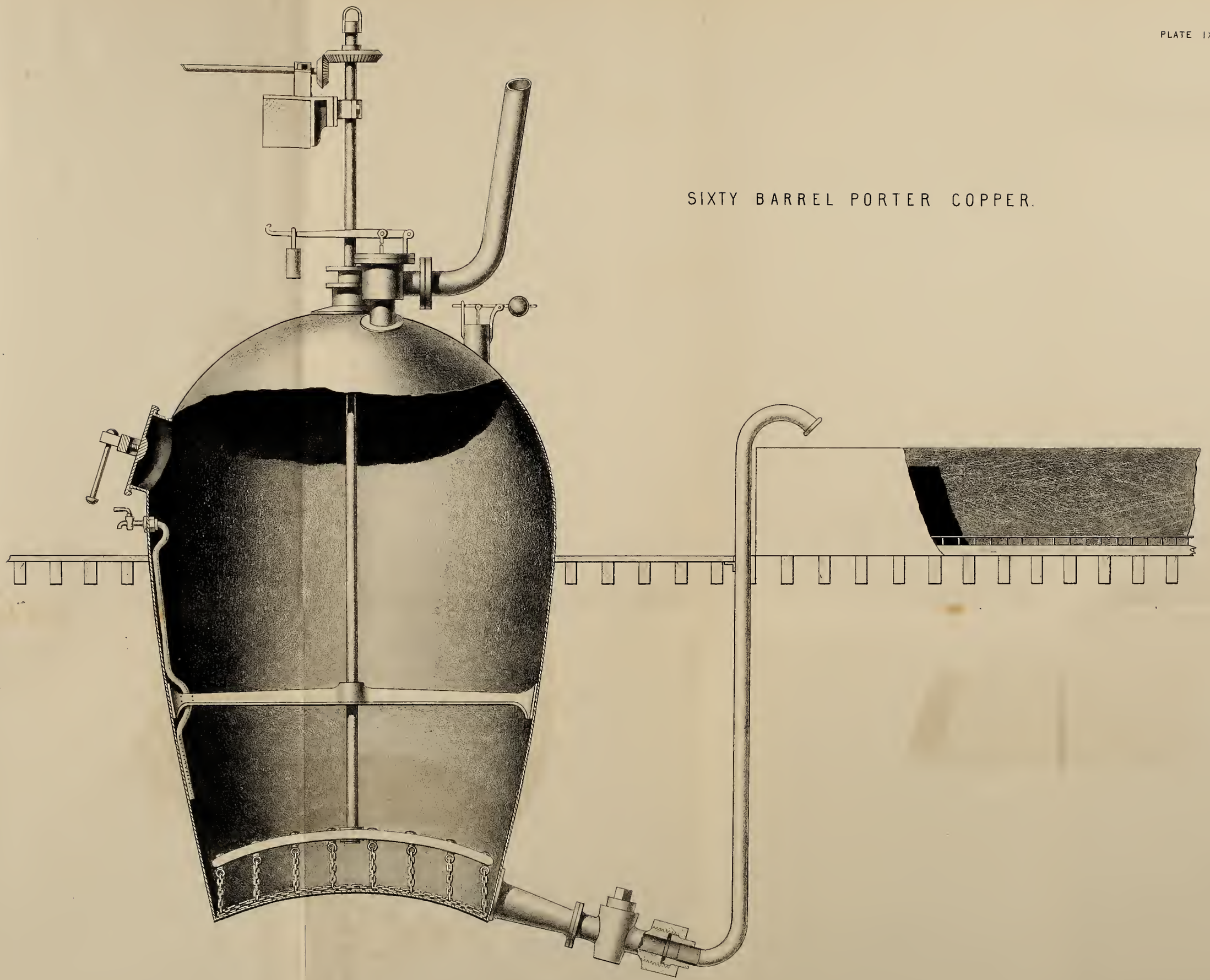
USUAL LONDON & DUBLIN PORTER MASH.

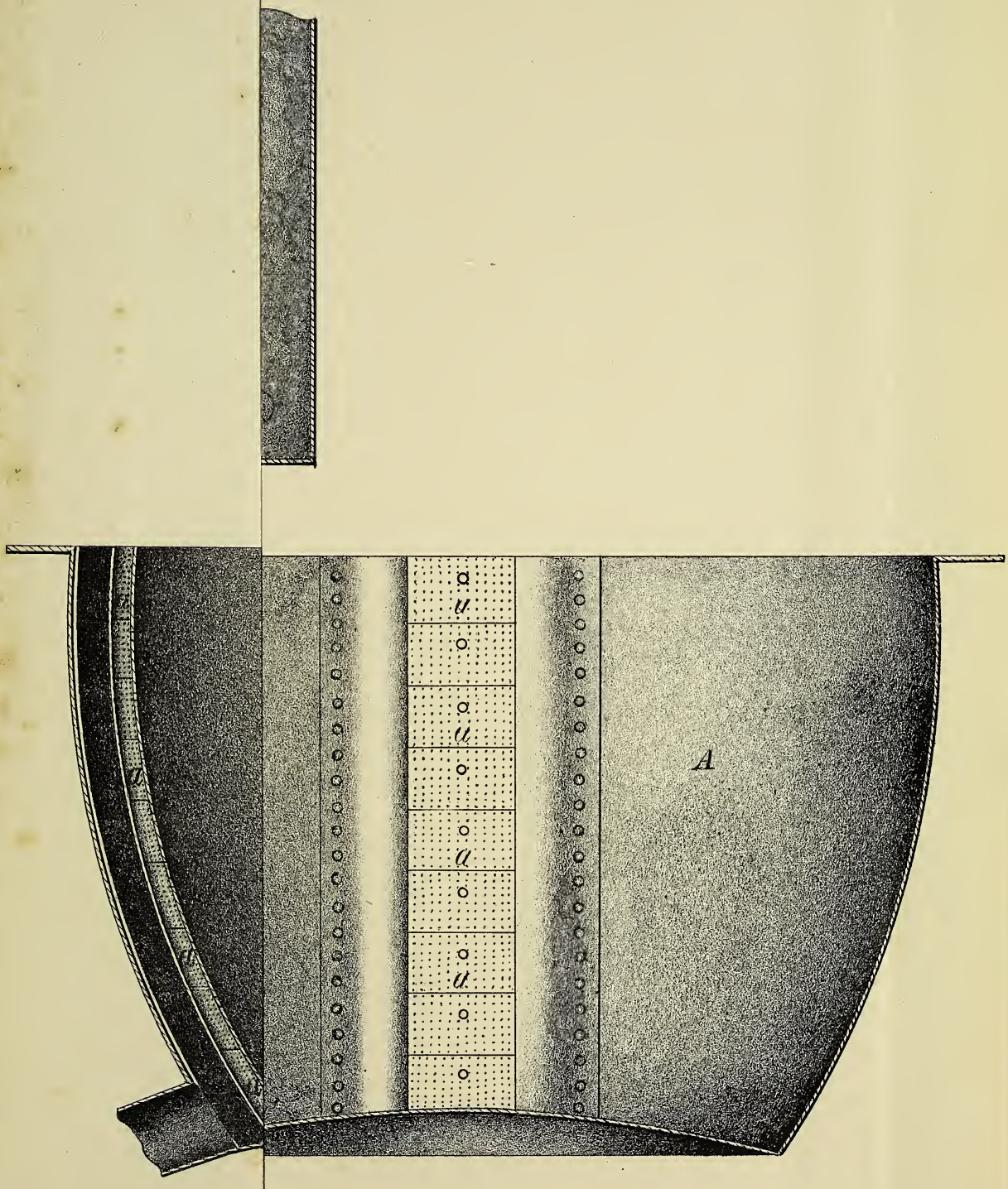
60 BARREL

EDINBURGH ALE COPPER.



SIXTY BARREL PORTER COPPER.

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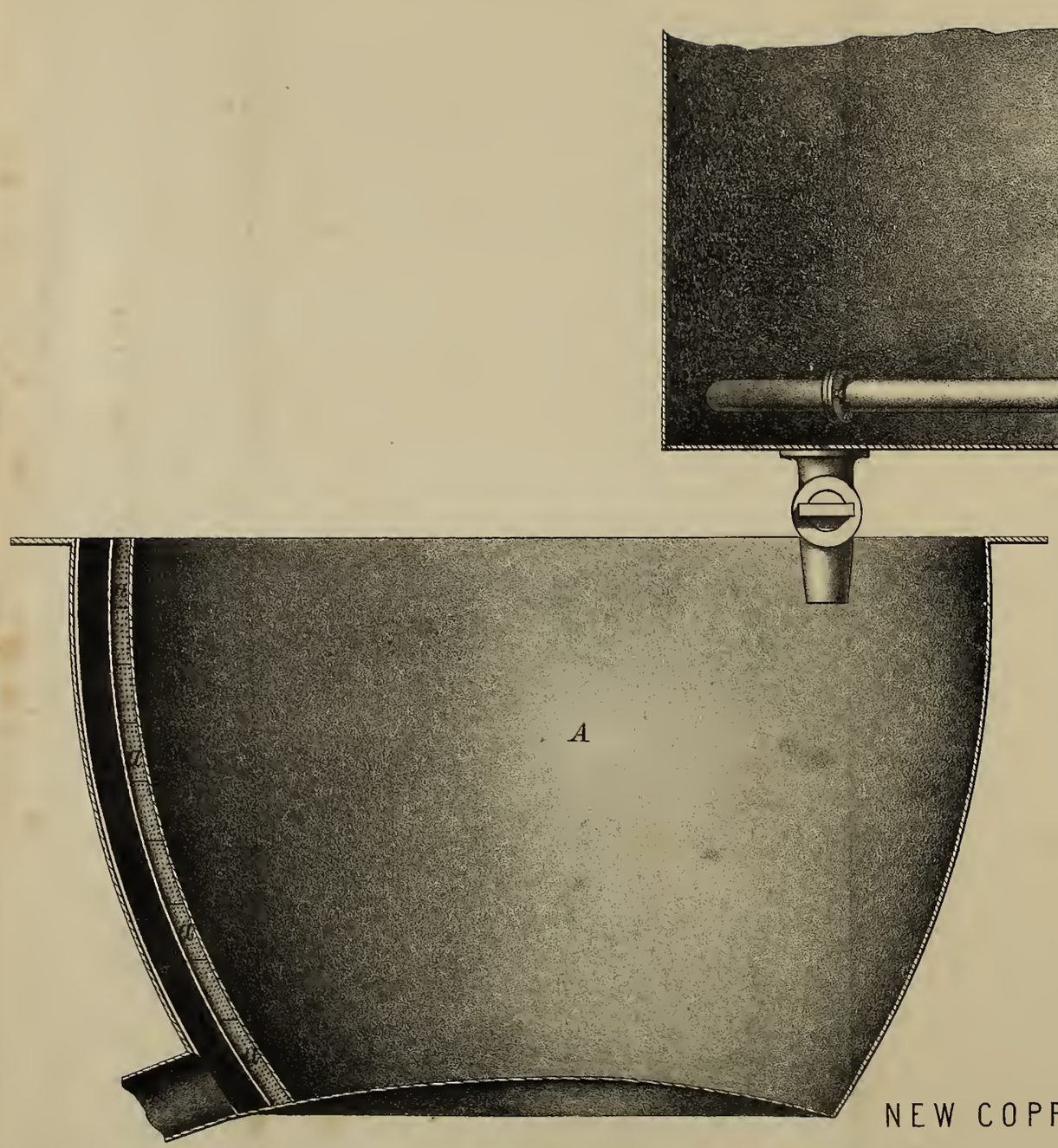

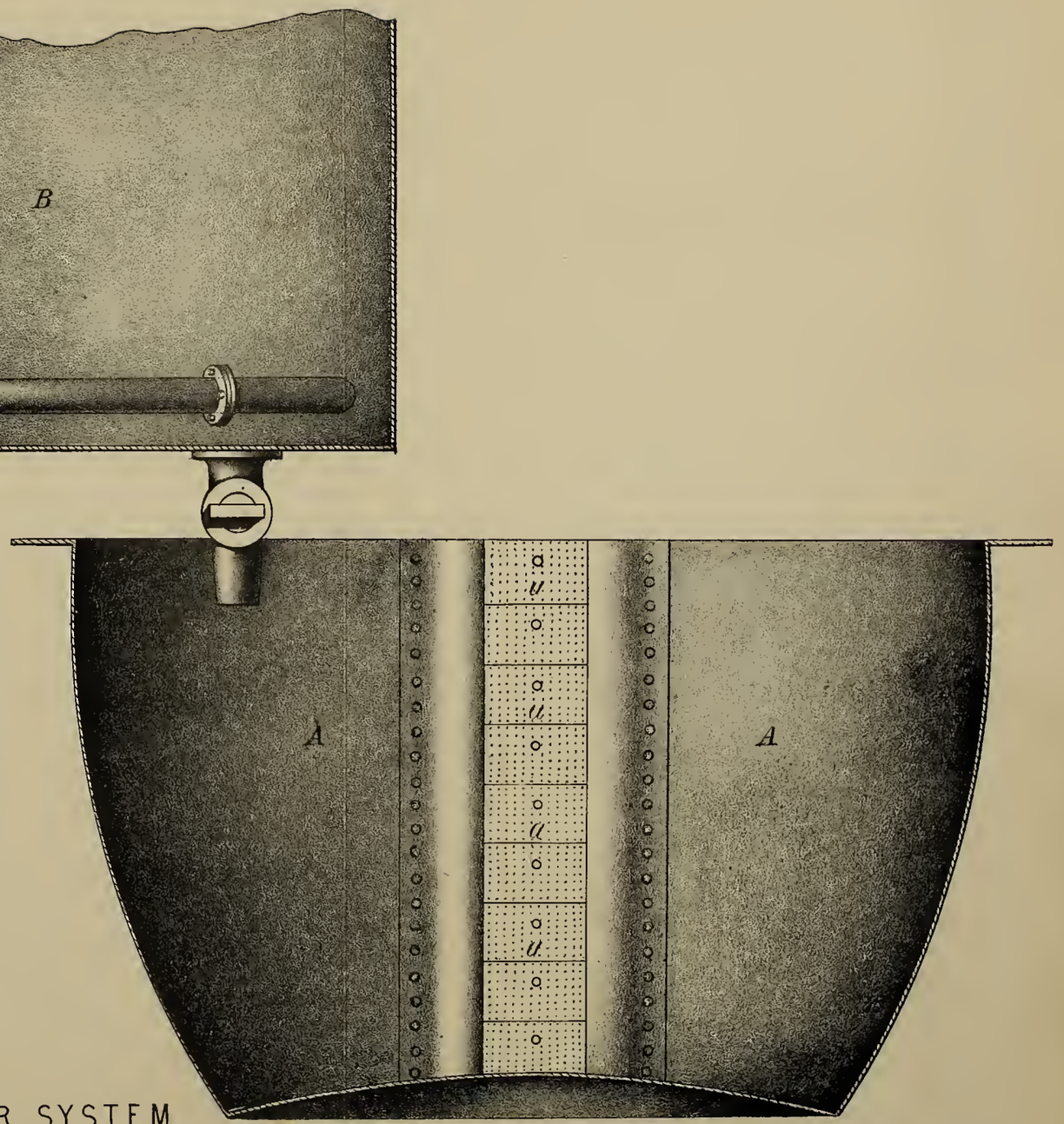

NEW COPPER SYSTEM
FOR HOP RE-BOILING.

ADDENDA.

RELATION OF PALE, AMBER, AND BLACK MALTS TO WEIGHT OF BARLEY, AND OF EXTRACTS TO THE WEIGHT OF MALTS.

Malt, when fully made, is as near as possible three-fourths of the weight of the producing barley. Thus the weight of malt may be found by multiplying the barley weight by ·75. 54 lbs. barley × ·75 = 40½ lbs. malt.

Malt, when properly mashed, yields an extract per bushel of three-fourths of its own weight. Thus malt multiplied by ·75 = extract. Malt of 40·5 × ·75 = 30⅜ lbs. of extract.

Black malt ought not to weigh more than $(\frac{60}{100})$ of the producing barley, anything heavier indicates the use of unmalted grain, its extract is equal to half its weight, thus:—

Barley = 54 lbs. × ·60 = 32·4.
Malt = 30·78 × ·50 = 16·2.

COPPER CHARGING.

All that a brewer wants to enable him to encounter a new brewery is his beer copper gauge, and its boiling-in power per hour in barrels; these ascertained, he has only to let his sparger go until he has quantity and strength, plus matter for copper and cooler evaporation.

A brew of a single boil may be placed thus: Wanted malt for 50 barrels of beer at ·60 in the fermenting tun. Taking average malt, it should yield for so thin a beer as this, say ·230 per quarter. 50 barrels at ·60 requires ·3000 of extract, and this, divided by ·230, shows nearly 13 quarters as the malt required. Copper charge 50 barrels at ·60 plus say 6 barrels to boil, and (8 per cent.) 4 barrels for cooler evaporation = 60 barrels at (·3000 ÷ 60 =) ·50. For casting quantity, to the 50 barrels wanted in the fermenting tun, add 4 for cooler, making 54 to cast at (·3000 ÷ 54 =) ·55·53 casting gravity.

As the copper dip becomes complicated by the presence of hop, and by the expansion of the wort, it is best to cast the copper by the gravity found as above. Casting by gravity is the only method within reach in the dome copper, and in this case (when the copper is under pressure) the wort is drawn from a cock attached to a pipe and rose going down to the wort inside, the wort rising by the effect of pressure.

In taking several boilings off one mash, they may be treated as one boiling, and the quantities and strengths of the coppers cast, or to be cast, carried forward and corrected in the last boiling. A copper charge book, recording daily experience, is necessary to facilitate these calculations.

SACCHAROMETERS.

To convert Dring & Fage to Allan, multiply by 2·77.
To convert Allan to Dring & Fage, divide by 2·77.

THERMOMETERS.

To convert degrees of Centigrade and Reaumer to degrees of Fahrenheit, and vice versa.

Centigrade to Fahrenheit multiply by the indication, say 100° by $\frac{9}{5}$ and add 32°, the result is in degrees of Fahrenheit. Thus, $100° \times \frac{9}{5} + 32° = 212°$.

Fahrenheit to Centigrade from indication, say 212°, substract 32° and multiply by $\frac{5}{9}$, the result will be in degrees of Centigrade. Thus, $212° - 32° \times \frac{5}{9} = 100°$.

Reaumer to Fahrenheit, multiply the indication, say 80° by $\frac{9}{4}$, and add 32°, the result will be in degrees of Fahrenheit. Thus, $80° \times \frac{9}{4} + 32° = 212°$.

Fahrenheit to Reaumer from indication, say 212°, substract 32°, and multiply by $\frac{4}{9}$, the result will be in degrees of Reaumer. Thus, $212° - 32° \times \frac{4}{9} = 80°$.

CAPACITIES OF BREWERS' MEASURES.

The Imperial Gallon	= 277·274 cub. in.	The Imperial Bushel	= 2218·2. cub in.
The English Barrel	= 9982 „	The Bushel of Malt Ground	= 2590 „

TABLE OF THE RELATIONS OF PRESSURES AND TEMPERATURES, INCLUDING THE ATMOSPHERE.

Pressure per square inch in lbs.	Degrees in Fahrenheit.	Pressure per square inch in lbs.	Degrees in Fahrenheit.
15 lbs.	= 212·0	80 lbs.	= 315·8
20 „	= 228·0	85 „	= 320·1
25 „	= 241·0	90 „	= 324·3
30 „	= 251·6	95 „	= 328·2
35 „	= 260·9	100 „	= 332·0
40 „	= 269·1	110 „	= 339·0
45 „	= 276·4	120 „	= 345·0
50 „	= 283·2	130 „	= 352·1
55 „	= 289·3	140 „	= 357·9
60 „	= 295·6	150 „	= 363·4
65 „	= 301·3	160 „	= 368·7
70 „	= 306·4	200 „	= 387·3
75 „	= 311·2		

Treatise on Steam, by John Sewell, in Weale's Series.

BREWING WATERS.

Two Analyses of Burton Water.

	No. 1.	No. 2.
Chloride of Sodium,	10·12	0·00
Sulphate of Potassa,	07·65	0·00
Sulphate of Lime,	18·96	54·40
Sulphate of Magnesia,	09·95	00·83
Carbonate of Lime,	15·51	09·93
Carbonate of Magnesia,	01·70	00 00
Carbonate of Iron,	00·60	00·00
Silicic Acid,	00·79	00·00
Chloride of Calcium,	00·00	13·28
Grains to the Gallon,	65·28	78·44

Two Analyses of Edinburgh Water.

	No. 1.	No. 2.
Chloride of Sodium,	11·71	07·78
Sulphate of Lime,	11·69	09·76
Chloride of Magnesia,	00·00	02·13
Chloride of Potassium,	02·86	00·56
Carbonate of Lime,	19·86	28·26
Carbonate of Magnesia,	00·00	05·48
Phosphates,	00·00	00·31
Oxide of Iron,	00·00	00·26
Silica,	00·68	00·32
Sulphate of Soda,	04·46	00·00
Sulphate of Magnesia,	10·90	00·00
Organic Matter,	00·00	01·56
Grains to the Gallon,	62·16	56·42

Two Analyses of Alloa Water.

	No. 1.	No. 2.
Carbonate of Lime,	04·30	18·23
Carbonate of Magnesia,	00·85	02·48
Sulphate of Lime,	04·77	12·83
Sulphate of Magnesia,	00·87	00·00
Chloride of Magnesium,	00·88	03·14
Chloride of Sodium,	01·85	08·46
Chloride of Potassium,	00·00	00·78
Silica,	00·60	00·36
Phosphates,	00·37	00·34
Oxide of Iron,	00·25	00·28
Sulphate of Soda,	00·00	05·38
Organic Matter,	02·32	01·18
Grains to the Gallon,	17·06	53·46

Two Analyses of London Water.

	No. 1.	No. 2.
Carbonate of Lime,	16·13	18·88
Sulphate of Lime,	00·00	00·00
Nitrate of Zinc,	00·23	00·00
Carbonate of Magnesia,	00·75	00·28
Chloride of Sodium,	01·01	01·94
Sulphate of Soda,	01·31	00·74
Silicate of Potash,	00·00	00·65
Sulphate of Potash,	00·44	00·38
Carbonate of Potash,	00·48	00·26
Silica,	01·59	00·69
Organic Matter,	01·26	00·73
Grains to the Gallon,	23·20	24·55

Two Analyses of Dublin Water.

	No. 1.	No. 2.
Carbonate of Lime,	12·42	14·21
Sulphate of Lime,	04·44	04·45
Carbonate of Magnesia,	01·23	01·22
Alkaline Chlorides,	01·84	01·83
Oxide of Iron,	01·24	00·24
Silica,	01·24	00·26
Organic Matter,	01·38	01·30
Grains to the Gallon,	23·79	23·51

TWO ANALYSES OF DOMESTIC WATERS.

Loch Katrine, Glasgow, No. 1. The Vartry, Dublin, No. 2.

	No. 1.	No. 2.
Organic Matter,	0·819	2·040
Sulphate of Lime,	0·000	0·667
Sulphate of Zinc,	0·378	0·000
Sulphate of Potash,	0·trace	0·000
Sulphate of Soda,	0·trace	0·000
Carbonate of Lime,	0·000	0·030
Carbonate of Magnesia,	0·152	0·007
Carbonate of Soda,	0·147	0·000
Carbonate of Iron,	0·trace	0·002
Chloride of Calcium,	0·trace	0·010
Chloride of Sodium,	0·448	1·212
Chloride of Potassium,	0·000	0·300
Alkaline Chlorides,	0·trace	0·000
Silica,	0·trace	0·044
Grains to the Gallon,	1·944	4·312

STATISTICS OF BEER EXPORTED FROM 1872 TO 1876, INCLUSIVE.

	1872. Barrels.	1873. Barrels.	1874. Barrels.	1875. Barrels.	1876. Barrels.	Value.
Dutch Possessions,	000,000	000,025	000,000	000,010	000,000	£0,000,161
France,	008,994	009,433	010,695	010,711	011,501	0,185,969
Spanish West Indies,	014,765	017,198	014,656	011,533	011,952	0,430,688
China, Hong-Kong, and Macao,	009,060	011,059	008,328	011,381	006,926	0,217,348
China, exclusive of above,	004,002	004,110	003,014	003,772	001,893	0,093,817
Japan,	002,494	002,849	002,444	002,008	000,992	0,061,235
Pacific Islands,	000,314	000,493	000,524	000,145	000,564	0,011,568
United States,	045,473	045,178	045,973	038,740	023,364	1,044,125
Venezuela,	000,280	000,145	000,271	000,321	000,365	0,009,188
Peru,	013,496	013,490	008,455	003,500	001,674	0,233,717
Bolivia,	000,477	000,416	000,235	000,212	000,124	0,007,703
Chili,	008,502	011,585	006,212	002,939	003,269	0,173,214
Brazil,	015,968	012,717	016,475	010,829	012,449	0,409,536
Uruguay,	002,355	004,220	005,181	000,967	000,432	0,073,688
Argentine Republic,	006,014	008,002	008,318	003,758	000,145	0,162,272
Channel Islands,	008,670	007,409	007,366	006,860	007,427	0,113,165
Gibraltar,	011,182	012,760	013,449	014,520	016,799	0,229,764
Malta and Gozo,	007,481	007,102	008,242	007,853	009,613	0,124,902
West African Settlements, Gambia, and Sierra Leone,	000,609	000,708	000,822	000,629	000,571	0,017,510
Ascension,	000,101	000,130	000,064	000,166	000,201	0,002,689
St. Helena,	000,535	000,670	000,669	000,685	000,495	0,011,522
Cape of Good Hope,	017,381	013,052	016,640	017,046	019,963	0,377,054
Natal,	004,308	003,628	004,160	005,860	004,839	0,094,888
Mauritius,	002,938	005,193	003,987	002,880	002,097	0,060,833
Aden,	000,136	003,431	002,118	002,568	001,647	0,029,699
British India, exclusive of Straits Settlements and Ceylon,	157,713	165,911	148,865	155,181	148,372	2,480,799
British India, Bombay, and Scinde,	050,747	066,583	053,749	052,858	051,833	0,842,080
British India, Madras,	019,695	025,910	021,348	021,729	026,462	0,354,792
British India, Bengal, and Burmah,	087,271	073,418	073,768	080,594	070,077	1,283,927
Straits Settlements,	004,306	002,651	006,490	003,889	006,313	0,102,484
Ceylon,	006,287	009,991	009,885	008,132	009,249	0,161,463
Hong-Kong,	005,058	006,949	005,314	007,609	005,033	0,123,531
Australia (West),	006,316	005,924	005,138	004,288	005,661	0,103,331
Australia (South),	006,943	008,757	008,203	005,922	007,089	0,168,443
Australia, Victoria,	019,888	033,755	034,186	022,244	027,424	0,661,952
New South Wales,	039,406	050,195	044,012	041,068	041,301	0,895,018
Australia, Queensland,	009,374	014,850	011,841	014,248	014,195	0,271,296
Australia, Tasmania,	000,481	000,941	001,047	000,471	000,658	0,018,876
Australia, New Zealand,	005,636	009,649	013,991	009,184	009,525	0,260,009
Fiji Islands,	000,000	000,000	000,000	000,000	000,086	0,000,547
Dominion of Canada,	010,534	012,754	015,413	009,614	007,668	0,271,091
Newfoundland and Labrador,	001,463	002,275	002,075	001,874	002,000	0,027,761
Bermudas,	003,577	004,133	004,619	005,302	004,680	0,069,309
British West India Islands,	020,895	020,844	021,092	019,346	016,977	0,390,473
British Guiana,	008,123	010,797	009,037	008,146	008,699	0,172,191
British Honduras,	000,520	000,578	000,585	000,491	000,341	0,012,684
Falkland Islands,	000,489	000,303	000,324	000,332	000,302	0,007,202
	650,257	724,171	679,280	632,415	602,247	£12,855,516

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